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TECHNICAL REPORT

TEST REPORT

T62-4-1

CABLE SPLICE REPAIR KIT

EVALUATION OF POLYSULFIDE-EPOXY POTTING COMPOUND KITS

by

S. M. Kalan

OMS 4230.11.03300.01

CAD

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REPORT T62-4-1

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Abstract:

(U) Two polysulfide-epoxy compound cable repair kits were investigated. The processability of the two part resin components was investigated over the ambient temperature range of -65 to 100 F, exothermic temperatures resulting from the reaction between the components were measured and protection of spliced MIL-C-13777 cable against damage by mechanical abuse (twist and impact) over an ambient temperature range of -65 to +125 F was determined. Under the conditions of this investigation, precondition-mix-pour at 70 and 100 F and precondition at 70-90 F -mix and pour at 0 and 25 F, both polysulfide-epoxy resin splice repair systems were effective in protecting latex rubber, extruded rubber, polyethylene and nylon/polyethylene insulated multiconductor cable repairs against mechanical abuse over the temperature range of -65 to 125 F. The potted splices exhibited electrical properties equal to or better than the basic cable and the compounds were effective in maintaining an adequate seal against moisture penetration and in maintaining excellent dielectric integrity under the mechanical abuse tests. (Author)

Abstract Classification:

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Annotation:

THE PROCESSABILITY OF TWO POLYSULFIDE EPOXY COMPOUND CABLE REPAIR KITS WAS INVESTIGATED OVER THE AMBIENT TEMPERATURE RANGE -65 TO 100 F. THE KIT EFFECTIVELY PROTECTED LATEX RUBBER, EXTRUDED RUBBER, POLYETHELENE AND NYLON/ POLYETHYLENE INSULATED MULTICONDUCTOR CABLE AGAINST MECHANICAL ABUSE AND MOISTURE PENETRATION. DIELECTRIC INTEGRITY WAS MAINTAINED.

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-- WAS INVESTIGATED OVER THE AMBIENT TEMPERATURE RANGE OF -65 TO 100 F,

-

-- EXOTHERMIC TEMPERATURES RESULTING FROM THE REACTION BETWEEN THE
-- COMPONENTS WERE MEASURED AND PROTECTION OF SPLICED MIL-C-13777
-- CABLE AGAINST DAMAGE BY MECHANICAL ABUSE (TWIST AND IMPACT) OVER AN
-- AMBIENT TEMPERATURE RANGE OF -65 TO +125 F WAS DETERMINED. UNDER
-- THE CONDITIONS OF THIS INVESTIGATION, PRECONDITION-MIX-POUR AT 70
-- AND 100 F AND PRECONDITION AT 70-90 F -MIX AND POUR AT 0 AND 25 F,
-- BOTH POLYSULFIDE-EPOXY RESIN SPLICE REPAIR SYSTEMS WERE EFFECTIVE
-- IN PROTECTING LATEX RUBBER, EXTRUDED RUBBER, POLYETHYLENE AND NYLON/
-- POLYETHYLENE INSULATED MULTICONDUCTOR CABLE REPAIRS AGAINST
-- MECHANICAL ABUSE OVER THE TEMPERATURE RANGE OF -65 TO 125 F. THE
-- POTTED SPLICES EXHIBITED ELECTRICAL PROPERTIES EQUAL TO OR BETTER
-- THAN THE BASIC CABLE AND THE COMPOUNDS WERE EFFECTIVE IN
-- MAINTAINING AN ADEQUATE SEAL AGAINST MOISTURE PENETRATION AND IN
-- MAINTAINING EXCELLENT DIELECTRIC INTEGRITY UNDER THE MECHANICAL
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-- CABLE REPAIR KITS WAS INVESTIGATED OVER THE AMBIENT
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-- RUBBER, EXTRUDED RUBBER, POLYETHELENE AND NYLON/
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Frankford Arsenal
Philadelphia 37, Pa.

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December 1961
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CABLE SPLICE REPAIR KIT

EVALUATION OF POLYSULFIDE-EPOXY POTTING COMPOUND KITS

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OBJECT

To investigate the processability and protective capabilities of two polysulfide-epoxy compound potting systems when used in connection with the protection and sealing of multiconductor cable splice repairs. To investigate the suitability of solderless crimp type connectors for connecting conductors associated with these repairs. To determine the suitability of this system as a replacement for the present soldering, tape wrapping, and vulcanizing procedures.

SUMMARY

(A: [illegible] Resin #40-[illegible]
B: PRC Resin 920)

Two polysulfide-epoxy compound cable repair kits were investigated. The processability of the two part resin components was investigated over the ambient temperature range of -65° to 100°F, exothermic temperatures resulting from the reaction between the components were measured and protection of spliced MIL-C-13777 cable against damage by mechanical abuse (twist and impact) over an ambient temperature range of -65° to +125°F was determined.

If the two part components of Compound A are preconditioned, mixed and poured at the same ambient temperature, the minimum processing temperature of Company A kit is limited to 50°F and Company B kit to 25°F. By preconditioning at 70-90°F, these minimums are lowered to 0°F.

The exothermal temperatures developed during the reaction-cure stage of the compounds are a function of the ambient temperature. Temperatures as high as 360°F were developed in a 1 5/8" diameter mold at 100°F ambient. The temperatures developed in the 2" to 2 1/2" kit molds enclosing Type 371065S MIL-C-13777 unjacketed cable assembly were approximately 30°F lower. The time duration of the reaction-cure cycle during which the temperature was higher than 220°F never exceeded 26 minutes.

Under the conditions of this investigation, precondition-mix-pour at 70°F and at 100°F and precondition at 70-90°F-mix and pour at 0°F and 25°F, both polysulfide-epoxy resin splice repair systems were effective in protecting latex rubber, extruded rubber, polyethylene and nylon/polyethylene insulated multiconductor cable repairs against mechanical abuse over the temperature range of -65°F to 125°F. The

potted splices exhibited electrical properties equal to or better than the basic cable and the compounds were effective in maintaining an adequate seal against moisture penetration and in maintaining excellent dielectric integrity under the mechanical abuse tests.

Nylon insulated crimp type solderless wire sleeve connectors and uninsulated crimp type solderless braid shield ring connectors gave satisfactory performance during this investigation.

Recommendation for ~~adoption of the polysulfide-epoxy potting method, solderless connectors, and processing techniques are~~ made in this report.

AUTHORIZATION

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Test Report T62-4-1, Cable Splice Repair Kit - Evaluation of Polysulfide - Epoxy Potting Compound Kits

Code	Product	Manufacturer
Compound A	Scotchcast Splicing Kit Scotchcast Resin #4	Minnesota Mining & Mfg. Co.
Compound B	PRC Splicing Kit PRC Resin 920	Products Research Company

THIS CODE SHEET WILL BE REMOVED FROM THE REPORT WHEN LOANED OR OTHERWISE DISTRIBUTED OUTSIDE THE DEPARTMENT OF DEFENSE

INTRODUCTION

In the present procedure for field splice repair[1], the conductors are joined by means of solder type sleeve connectors and are individually insulated with rubber tubing and rubber splicing vulcanizing tape. The wire bundle is then wrapped with rubber splicing tape and overwrapped with black vulcanizing tape extending over the cable jacket on each side of the splice. Finally the entire assembly is cured between molds in a portable electrical powered vulcanizing kit at 280-315°F for approximately 30 minutes. This procedure has been used successfully since 1938.

However, the development of new fluid self-curing potting compounds and insulated crimp type solderless connectors indicates that a major simplification in the cable repair process is feasible.

A preliminary investigation in 1956[2] concluded that a cable repair kit was feasible and recommended that a more thorough investigation be made.

Since then, thermoplastic wire dielectric materials, polyethylene and nylon, have been introduced in multiconductor cable MIL-C-13777 construction. The insulations now in use in MIL-C-13777 cable are rayon braid covered latex natural rubber, extruded natural rubber and buna S, and rayon braid and extruded nylon covered polyethylene. Also, nylon covered solderless wire connectors are now available.

This program was initiated to more completely investigate polysulfide-epoxy potting compounds for cable splice field repair systems and covers the following features:

1. These resins cure exothermally and generate a considerable amount of heat energy in the process. The temperatures resulting from this reaction and the effect on the wire and connector insulating materials will be determined.

2. The limitations imposed by ambient temperatures over the range of -65°F to +100°F on the potting procedures and capabilities will be investigated.

3. The ability of the insulated crimp type solderless connector to provide reliable electrical continuity of the joined conductors and to provide dielectric integrity between adjacent joints will be determined.

---

[1] Dept. of the Army Technical Manual TM 9-1649 Dec. 1945, pp 23-52
[2] Frankford Arsenal Report S-5265, 10 July 1956

DESCRIPTION OF MATERIALS

Potting Compound Systems

Two materials supplied with repair kit accessories were evaluated.

1 - Compound A Kit (fig. 1)

The kit consists of a two part resin, packaged in a two compartment mylar film bag, Unipak, and a mold consisting of a vinyl copolymer cylinder 9" long x 2 1/32" I.D. x 2 11/32" O.D. and two polyethylene tapered end caps each equipped with a filling funnel, figure 1.

The mixing of the components is accomplished by exerting pressure on one compartment sufficient to cause rupture of separator. The parts are then mixed by a repeated kneading operation on the still sealed bag. This bag is emptied by pouring the contents through a spout formed by clipping one of the corners. Filling of the mold is accomplished by pouring the mixed compound into one of the funnels while maintaining the other end at a slightly higher elevation.

Unipak containers are available in three sizes

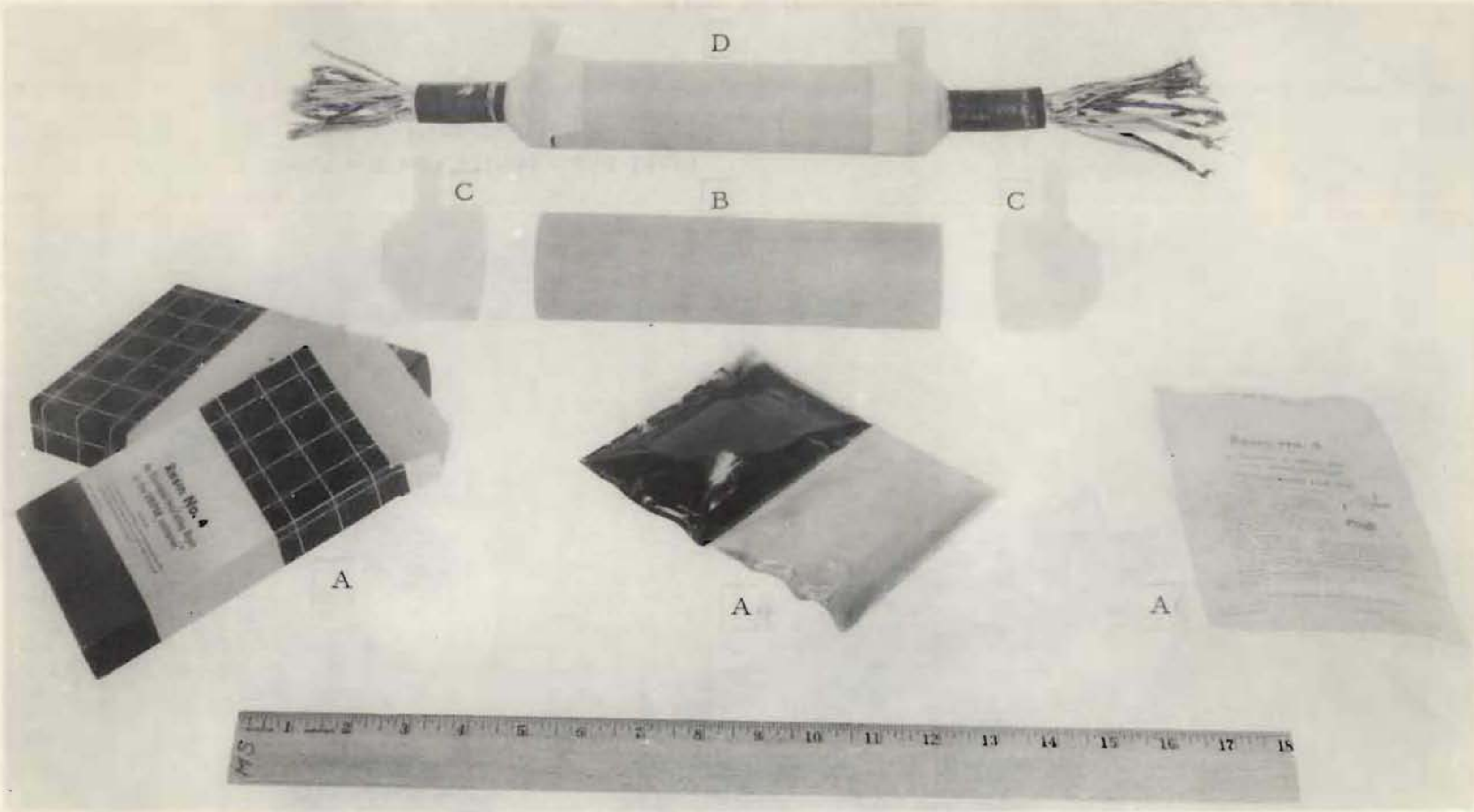
Unipak A - 2 3/4 fluid ounces

Unipak B - 6 1/4 fluid ounces

Unipak C - 12 1/2 fluid ounces

2 - Compound B Kit (fig. 2)

Originally it was proposed that the two part resin, would be packaged in a two compartment cylinder equipped with a mixing piston and sealed outlet. Mixing would be accomplished by back and forth motion of the piston containing an orifice passage. Emptying of the cylinder would be accomplished by forcing the mixed compound through the punctured outlet seal. However, this scheme had not been perfected when the investigation was started. The kit furnished for evaluation consisted of the two part resin furnished in two bottles, 9.85 ounce packages and a one-piece split mold of .030" cellulose acetate butyrate 9 1/2" long x 2 1/2" diameter tapered at each end to approximately 1" diameter. The mold was filled by pouring the mixed compound through an opening 6 1/2" long x 1/2" wide x 1/2" high.



A - Resin Packaging
B - Mold Sleeve
C - End Caps
D - Potted Splice

Figure 1. Cable Repair Kit for Multiconductor Cable - Cables - Compound A Kit

A - Mix Cylinder and Mold
B - 2-Part Bottled Resin
C - Potted Splice

Figure 2. Cable Repair Kit for Multiconductor Cables - Compound B Kit

3. When the two part fluids are properly mixed, the resultant mixture will cure with low volume shrinkage at normal room temperature ambients to tough resilient dielectric compounds having the following properties:

Property[1]	Compound A	Compound B
Volume shrinkage	1.5%	2.0%
Dielectric strength[2]	200-400 volts per mil.	
Dielectric constant at 1000 cps	4.9	5.0
Volume resistivity-ohm cm	3×10^{13}	10^{14}
Water absorption[3]	0.5%	0.5%
Specific gravity	-	1.23

[1]At 30°C

[2]Short time method

[3]24 hrs. immersion

Connectors

The wires of the splice were joined by solderless crimp type connectors with the following descriptions.

1. For AWG 14 and 18 wires - Burndy nylon insulated Insulink Type YSE 14-H.

2. For AWG 12 wires - Burndy nylon insulated Insulink Type YSE 10.

3. For wire shielding - Burndy uninsulated Hyring types YIC 261 and YOC 220 and 3/16" I.D. tinned copper shield tubing designated as Alpha 1230.

4. Crimping tools - Burndy MR 8-33T for the wires and MR 8 PV-11 for the shield braids.

Cable

The cable used in this investigation conformed with the requirements of MIL-C-13777 Revision B. The construction details are illustrated in figures 3 and 4. The insulating materials are described below:

Cable 1 - Type 371065S Composition B is a neoprene jacketed cable containing 37 conductors insulated with 85% natural latex rubber and a treated rayon braid covering.

Cable 2 - Type 371065S Composition A is a neoprene jacketed cable containing 37 conductors insulated with 60% natural extruded rubber and a treated rayon braid covering.

Cable 3 - Type 211055 Composition F is a neoprene jacketed cable containing 21 conductors insulated with a treated rayon braid covered polyethylene.

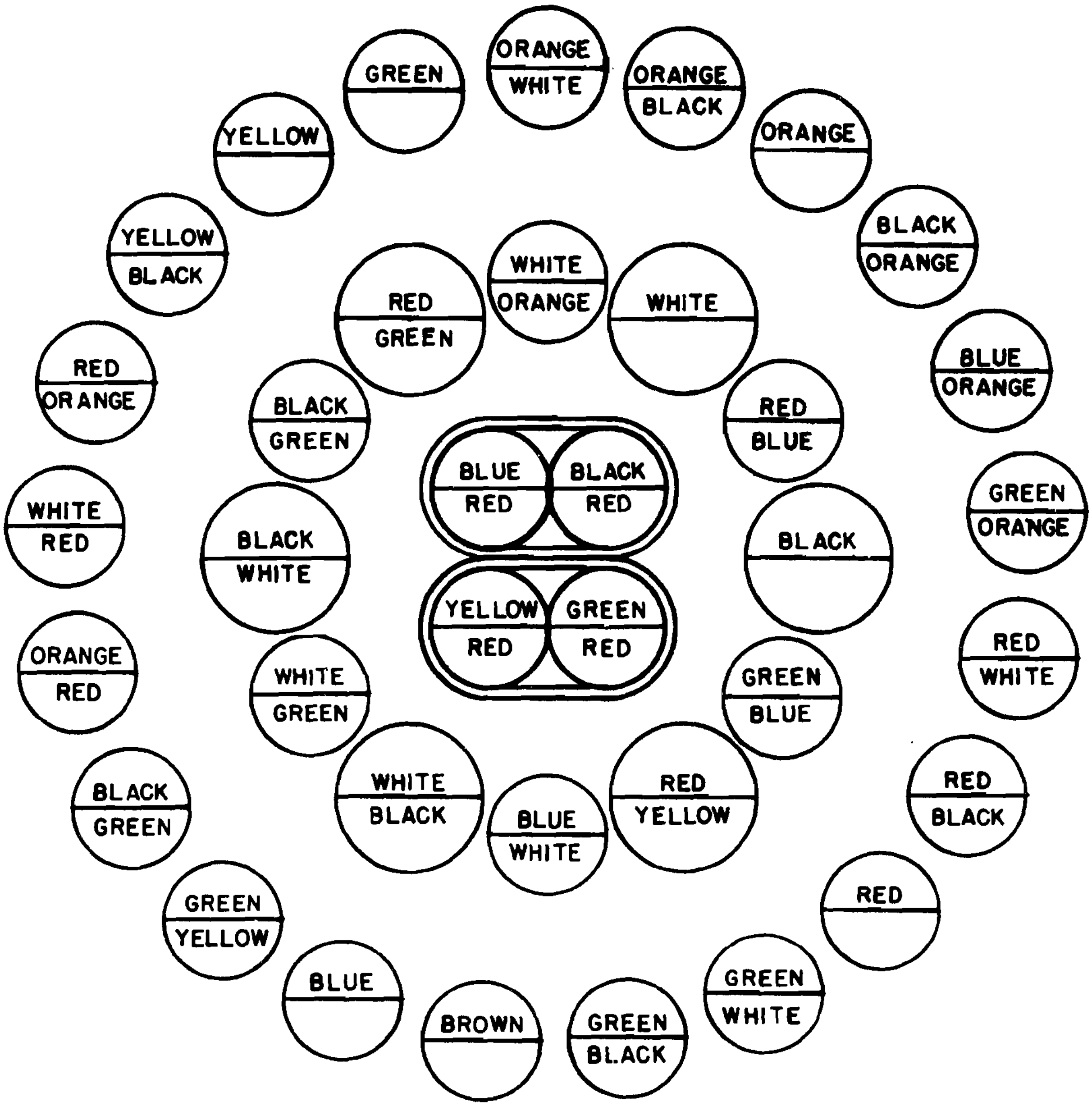
Cable 4 - Type 211055 Composition F is a neoprene jacketed cable containing 21 conductors insulated with an extruded nylon covered polyethylene.

DISCUSSION

During the chemical reaction resulting when the promoter and resin components are mixed, a considerable amount of energy is released in the form of heat. The temperatures developed, if excessive may cause a loss in the insulation wall thickness due to undesirable migration of the thermoplastic dielectric materials. Polyethylene and nylon with melting points of 220°F and 415°F are susceptible to such a degeneration of cable quality.

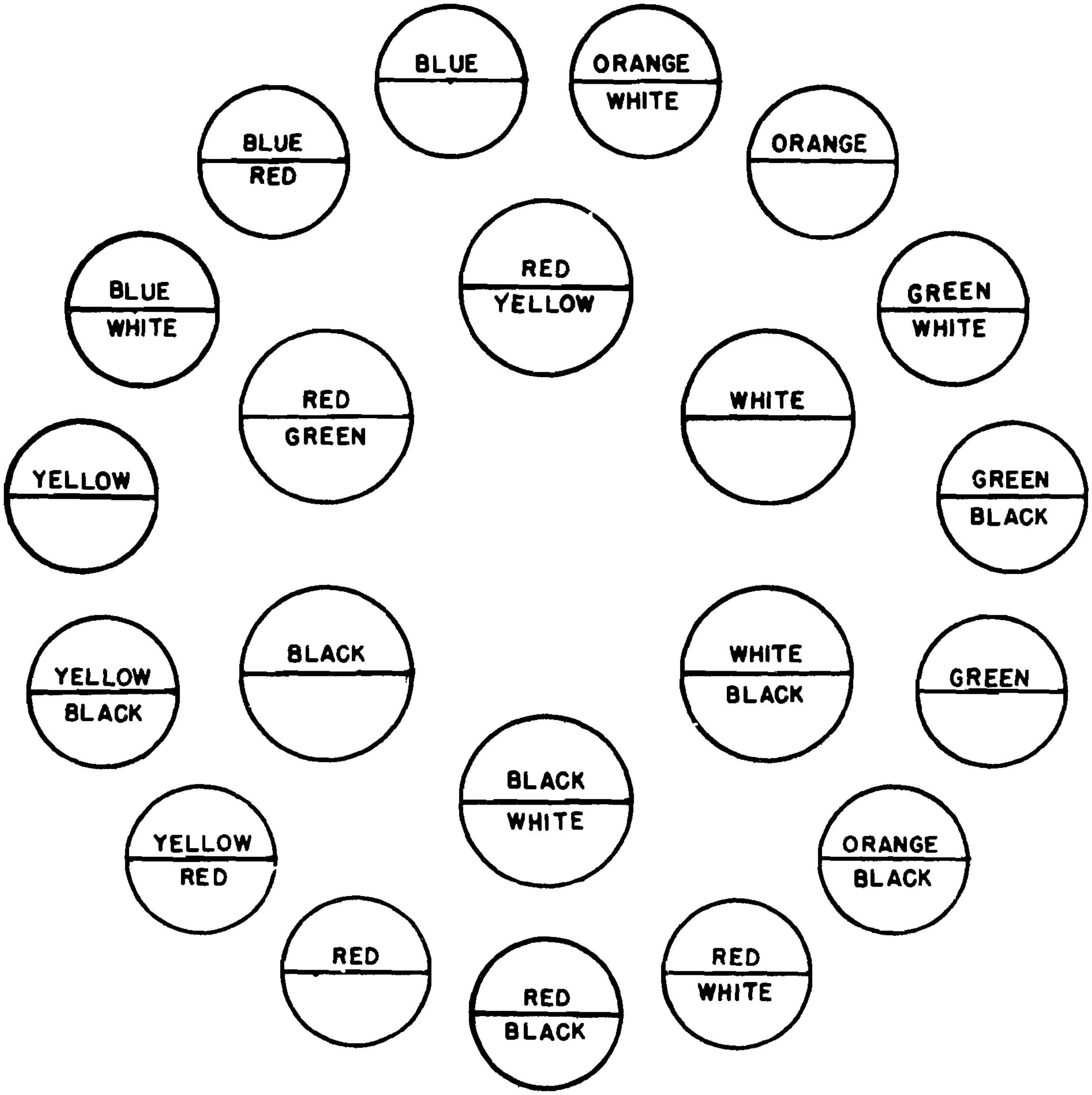
In the field repair of cables, a wide range of temperatures, -65°F to +125°F, are encountered. At low ambient temperatures, the fluid mixture may be too viscous to pour and curing may be inhibited. At high temperatures, the exothermal reaction temperatures may be disastrous. Within practical limits, it is desirable that repairs can be readily accomplished within as wide a range of ambient temperature as possible with a minimum requirement for special portable shelter equipment.

This investigation was performed in three phases. The first two preliminary phases explored the effect of ambient temperatures on the



CABLE TYPE: 371065S

Figure 3. Cross Section Showing Grouping and Color Coding of the Conductors - Double Circle Indicates Shielded Conductors



CABLE TYPES: 211055

Figure 4. Cross Section Showing Grouping and Color Coding of the Conductors

processability of the compounds and the temperatures developed during the curing cycle. On the basis of this preliminary information, the conditions for the cable splice repair tests were crystallized.

In the final phase, cable splices were potted at three ambient temperatures with aged and unaged resins and subjected to twist and impact tests at low and elevated temperatures. The sealing effectiveness of the potted splices was determined by exposure to a high humid atmosphere. Because of the sensitivity to moisture presence, the evaluation was made by testing for (a) d.c. insulation resistance, (b) 1000 cps capacity and (c) 60 cps dielectric strength before and after the exposure conditions.

TEST PROCEDURES AND RESULTS

Compound Tests

In this phase of the investigation, tests were made on the compounds alone to observe the conditions of the components, their processing characteristics and the heat developed during the curing reactions at various ambient temperatures. The following procedures were used.

1. Precondition the components at various temperatures (T_c) for 5-18 hours.

2. Pour the components (promoter added to resin) into 12-ounce paper drinking cups at ambient temperatures ranging from -65°F to 100°F (T_p).

3. Mix the components with an aluminum paint stirring paddle (fig. 5) during the addition process.

4. Pour 50 cc into a 50 ml. pyrex beaker (1 5/8" dia. x 2" high) and insert a constantin-iron thermocouple junction into the volumetric center of the mass. Temperature-time readings were recorded with an automatic recording potentiometer connected to the thermocouple leads during steps 3 and 4. In this step, the reaction was allowed to proceed with no further stirring unless otherwise noted in table I.

5. Below 15°F, the compound components stiffened to such a degree that proper mixing and pouring were impossible. Therefore,

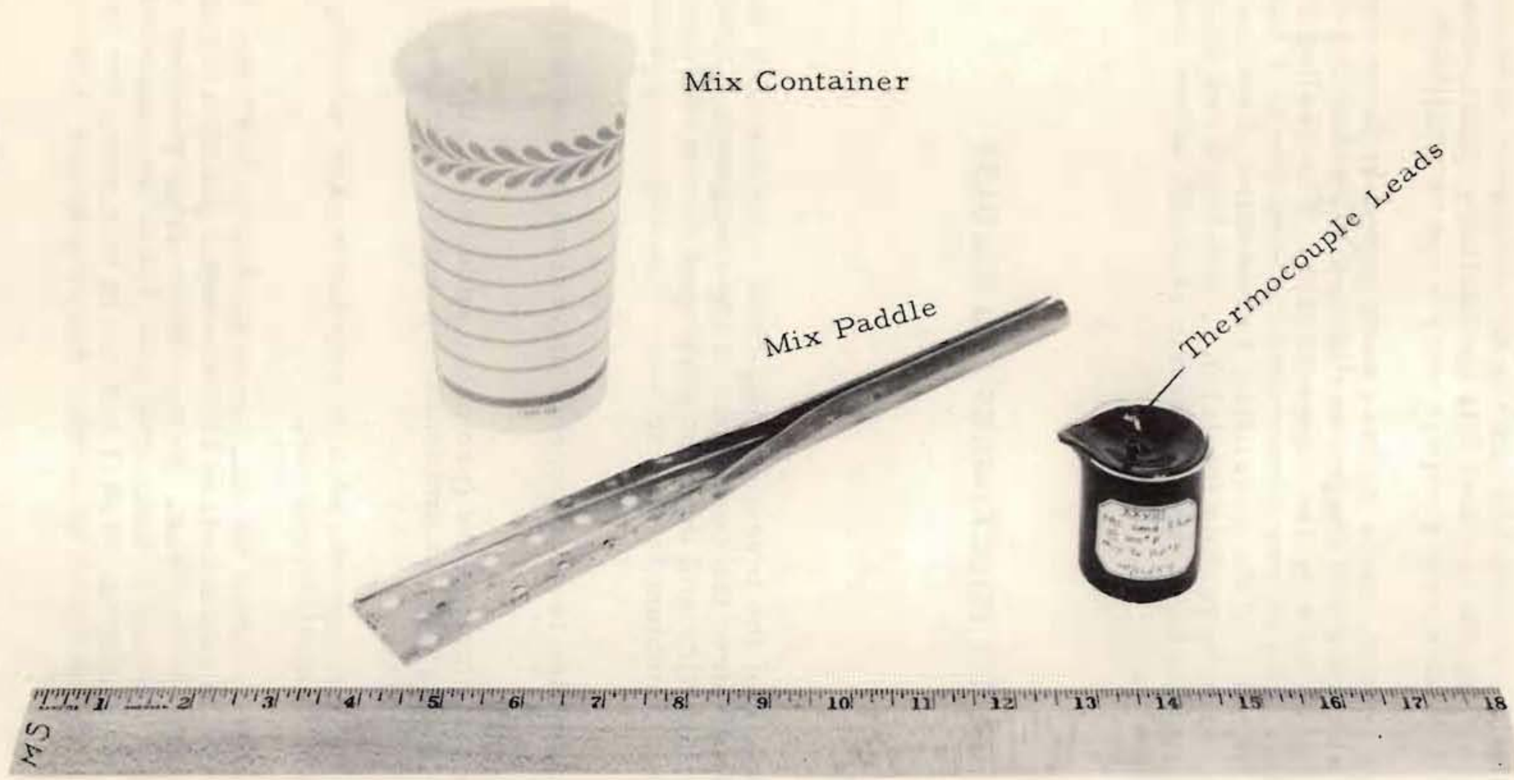


Figure 5. Cable Repair Kit for Multiconductor Cables - Compound Tests

test steps 2, 3 and 4 at temperatures below 15°F were performed with the fluid components preconditioned at normal room temperature (step 1).

6. At ambient temperatures of the order of 0°F and lower, the chemical reaction between the resins and promoter was almost completely inhibited. In these cases, the mixed components were transferred to normal room conditions after 2-18 hours at the mixing temperature ambient conditions (step 4).

7. The results are summarized in table I and figures 6-10.

Except for the normal room temperature (70-90°F) conditions, walk-in environmental chambers were utilized for all tests.

Cable Thermal Test

The temperature developed within a cable splice due to the exothermal reaction of the compound components is dependent on the rates of heat dissipation due to exposed surface radiation and to conduction by the copper conductors.

These tests were made to determine the penetration as reflected by temperature gradient and the effect of the cable copper on the temperature-time characteristic of the compound. The diameter of the potted assembly is slightly larger than that of the 50 ml. beaker used in the compound tests and, therefore, any effect observed is largely due to the presence of the metal.

The specimens for these tests were prepared from Type 371065S MIL-C-13777 cable (fig. 3) which consists of 2 shielded pairs of AWG 18 wire, six AWG 14 wires and 27 AWG 18 wires. This represents approximately 75,000 circular mils of copper cross section.

For this test, seven inches of the jacket material (chloroprene) was stripped from the middle section of a 24-inch length of cable. Thermocouple (iron-constantin) junctions were inserted as illustrated in figure 11. This section was then enveloped by a repair splice mold and the thermocouple leads were brought out through the fill openings of the mold and connected to a 6-point automatic temperature recorder, Brown Instrument Co. Model 153 x 62 P6-X-16.

Immediately after mixing at room ambient temperature (70-80°F), the potting compounds were poured into their respective mold-cable assemblies. Compound A was mixed in its Unipak container (1 size B plus 1 size C) and Compound B was mixed in an 800 ml. beaker (2 - 9.85 oz. kits).

Table I. Compound behavior

Specimen No.	Temperature - °F Tc(1)	Tp(2)	T(3)	Resin Max. T	Mix and Flowability(4)	Remarks
			Compound A			
4	100	100	100	303	E	
2	70	70	70	282	E	
16	25	25	-	50	P	Continuous Mix
9	82	25	25	110	E	
8	10	10	10	110	P	Mixed 79 min. before pour
19	74	5	5	-	P	Reaction inhibited
			75	90		
22	82	-25	-25	-	P	Reaction inhibited
			75	140		
13	87	-40	-40	-	P	Reaction inhibited
			87	122		
14	89	-65	-65	-	P	Reaction inhibited
			89	127		
			Compound B			
28	100	100	100	360	E	
27	74	74	74	305	E	
17	25	25	25	78	F	
18	72	25	25	118	E	
26	88	4	4	128	E	
24	86	-25	-25	-	E	Reaction inhibited
			78	97		
21	76	-40	-40	-	G	Reaction inhibited
			78	138		
23	80	-65	-65	-	P	Reaction inhibited
			80	150		

(1) Resin precondition temperature
(2) Resin mix and pour ambient temperature
(3) 50 ml. specimen ambient temperature
(4) E= Excellent G = Good P = Poor

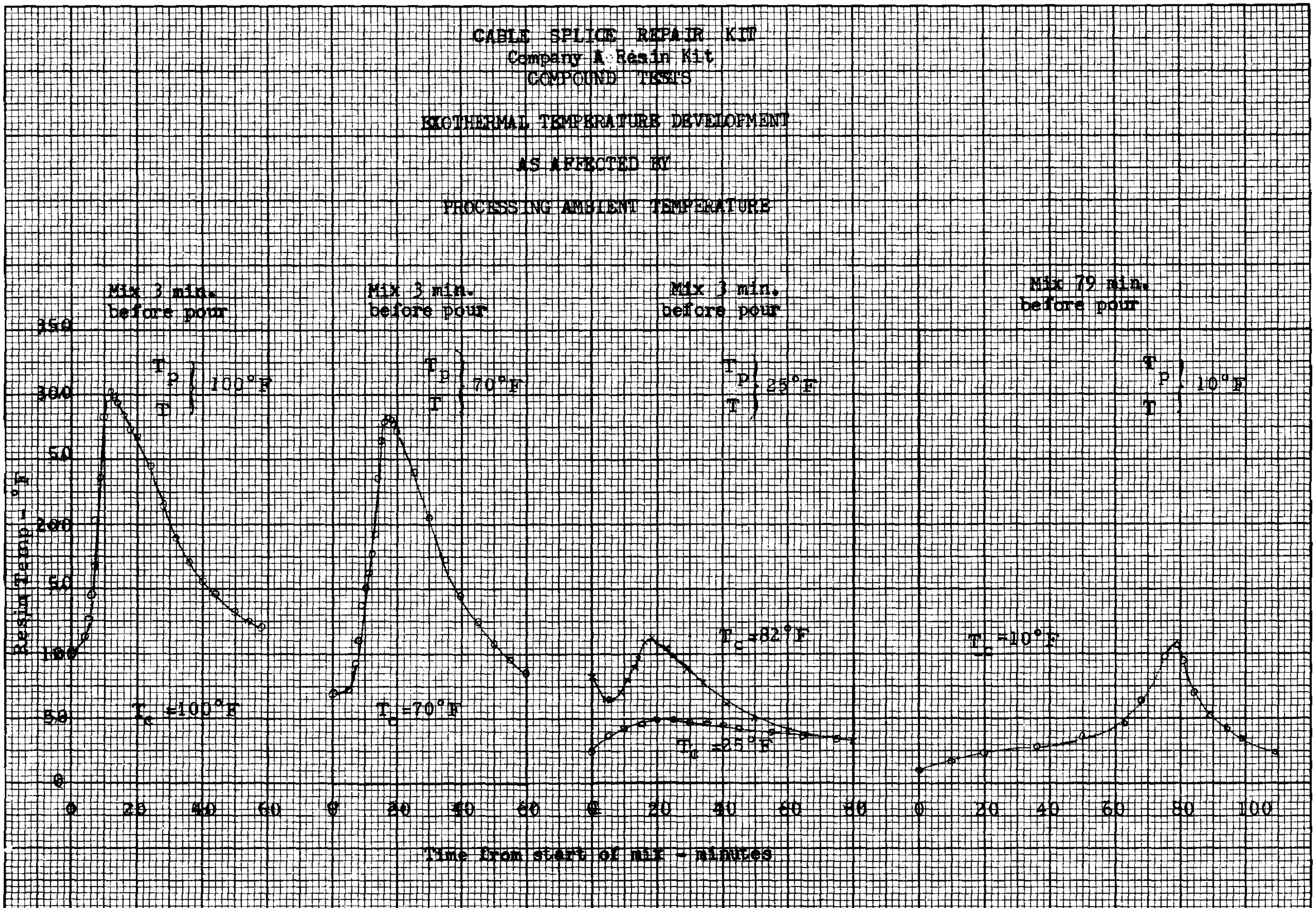

CABLE SPLICE REPAIR KIT
Company A Resin Kit
COMPOUND TESTS
EXOTHERMAL TEMPERATURE DEVELOPMENT
AS AFFECTED BY
PROCESSING AMBIENT TEMPERATURE
Mix 3 min. before pour
Mix 3 min. before pour
Mix 3 min. before pour
Mix 79 min. before pour
T_p T 100°F
T_p T 70°F
T_p T 25°F
T_p T 10°F
T_c =100°F
T_c =70°F
T_c =82°F
T_c =25°F
T_c =10°F
Resin Temp - °F
350
300
250
200
150
100
50
0
0
20
40
60
0
20
40
60
0
20
40
60
80
0
20
40
60
80
100
Time from start of mix - minutes

Figure 6.

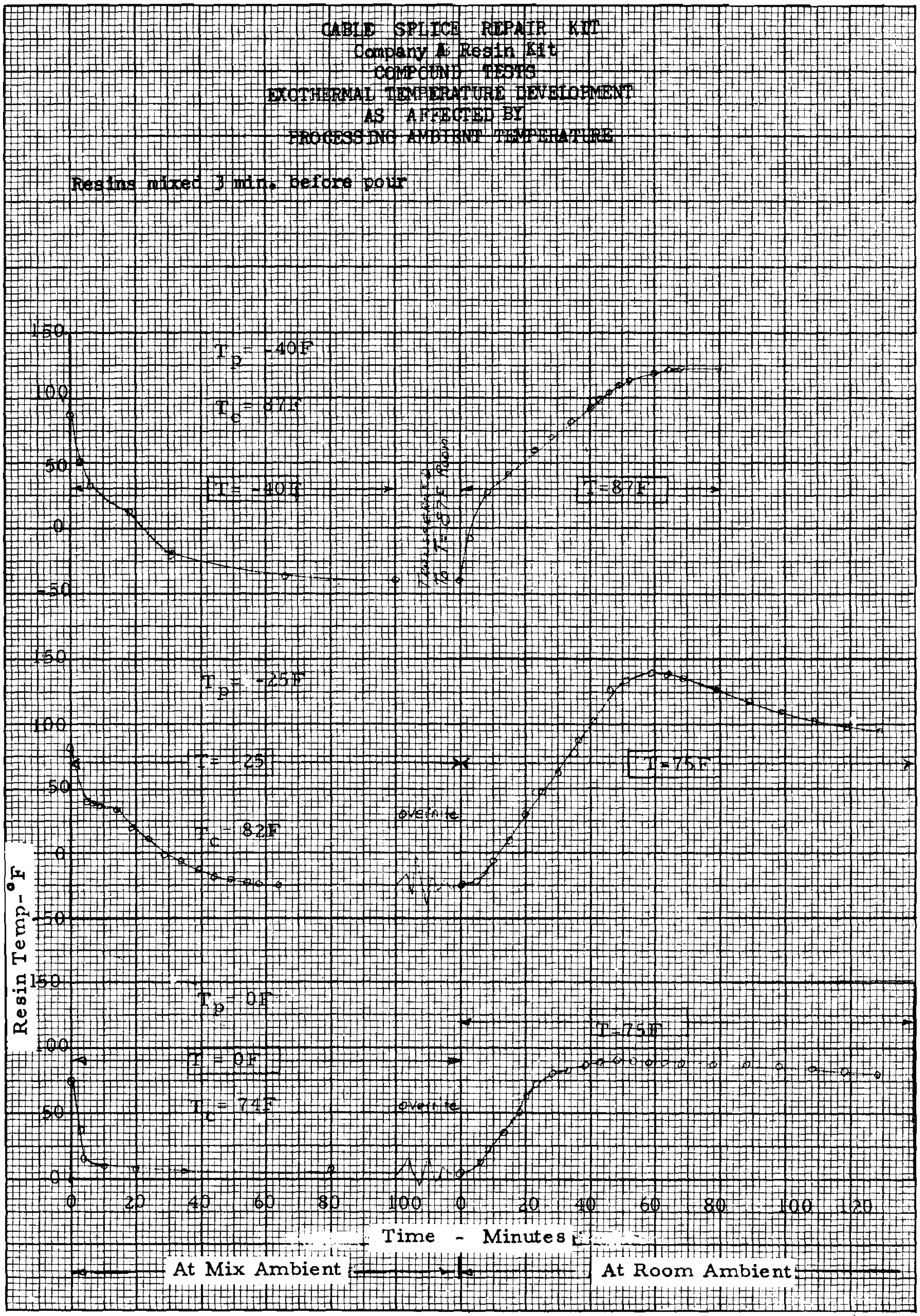

CABLE SPLICE REPAIR KIT
Company A Resin Kit
COMPOUND TESTS
EXOTHERMAL TEMPERATURE DEVELOPMENT
AS AFFECTED BY
PROCESSING AMBIENT TEMPERATURE
Resins mixed 3 min. before pour
Tp = -40F
Tc = 87F
T = -40F
T = 87F
Tp = -25F
T = -25
T = 75F
Tc = 82F
overlite
Tp = 0F
T = 75F
T = 0F
Tc = 74F
overlite
Resin Temp-°F
150
100
50
0
-50
0
20
40
60
80
100
120
Time - Minutes
At Mix Ambient
At Room Ambient

Figure 7.

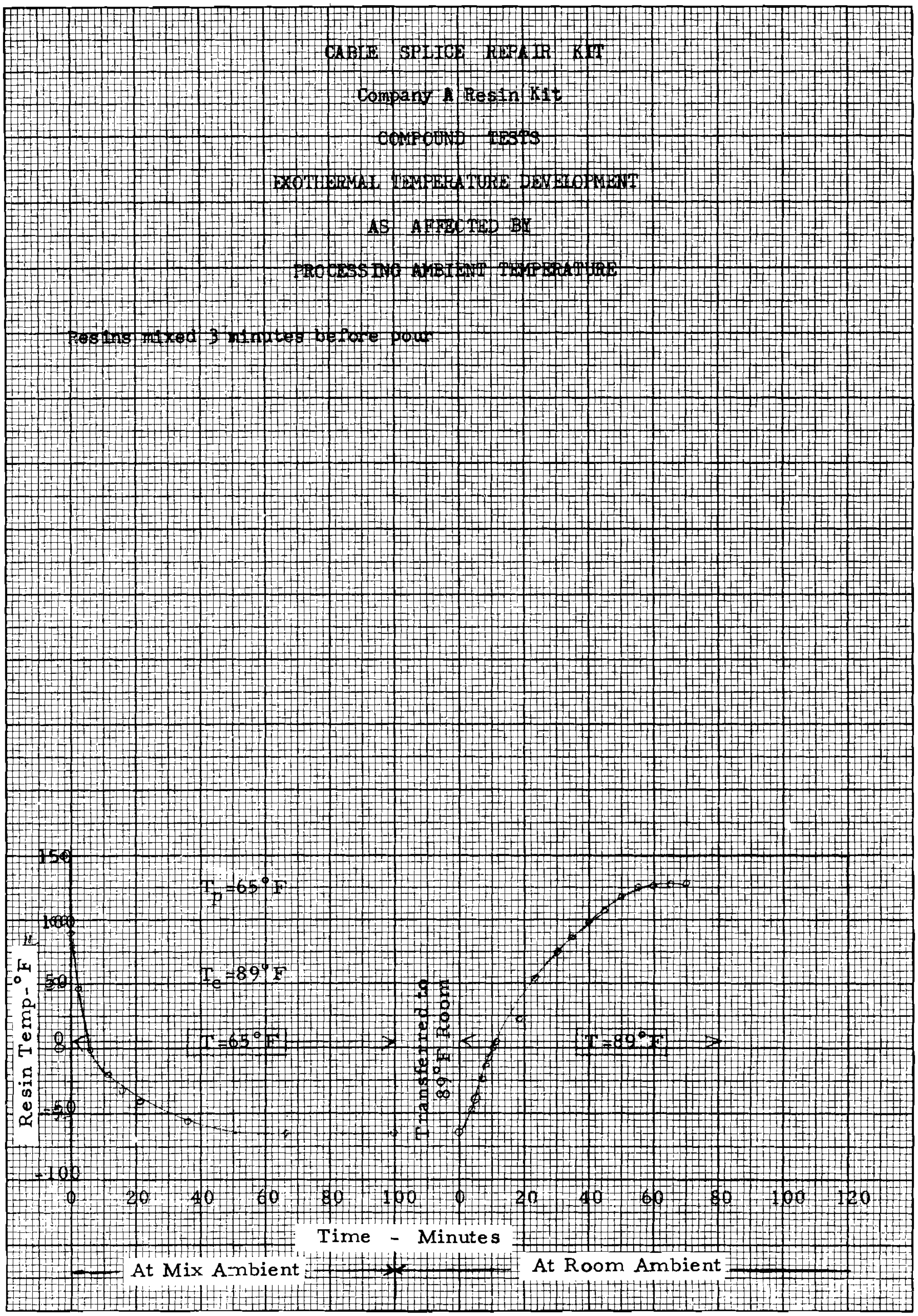

CABLE SPLICE REPAIR KIT
Company A Resin Kit
COMPOUND TESTS
EXOTHERMAL TEMPERATURE DEVELOPMENT
AS AFFECTED BY
PROCESSING AMBIENT TEMPERATURE
Resins mixed 3 minutes before pour
Resin Temp-°F
150
100
50
0
-50
-100
Tp=65°F
Te=89°F
T=65°F
Transferred to 89°F Room
T=89°F
0
20
40
60
80
100
0
20
40
60
80
100
120
Time - Minutes
At Mix Ambient
At Room Ambient

Figure 8.

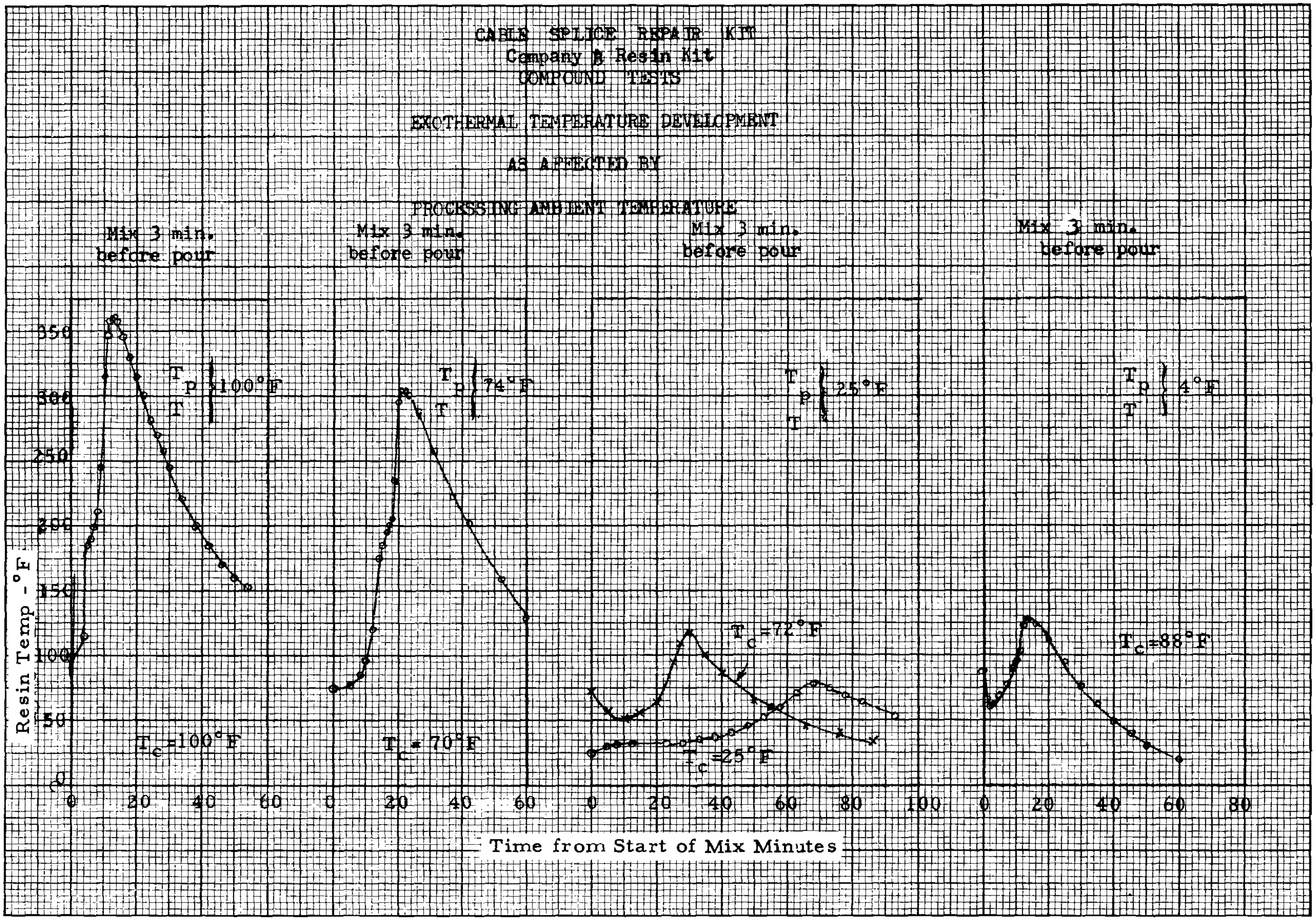

CABLE SPLICE REPAIR KIT
Company B Resin Kit
COMPOUND TESTS
EXOTHERMAL TEMPERATURE DEVELOPMENT
AS AFFECTED BY
PROCESSING AMBIENT TEMPERATURE
Mix 3 min. before pour
Mix 3 min. before pour
Mix 3 min. before pour
Mix 3 min. before pour
Tp T 100°F
Tp T 74°F
Tp T 25°F
Tp T 4°F
Tc=100°F
Tc = 70°F
Tc=72°F
Tc=25°F
Tc=88°F
Resin Temp - °F
0
50
100
150
200
250
300
350
0 20 40 60
0 20 40 60
0 20 40 60 80 100
0 20 40 60 80
Time from Start of Mix Minutes

Figure 9.

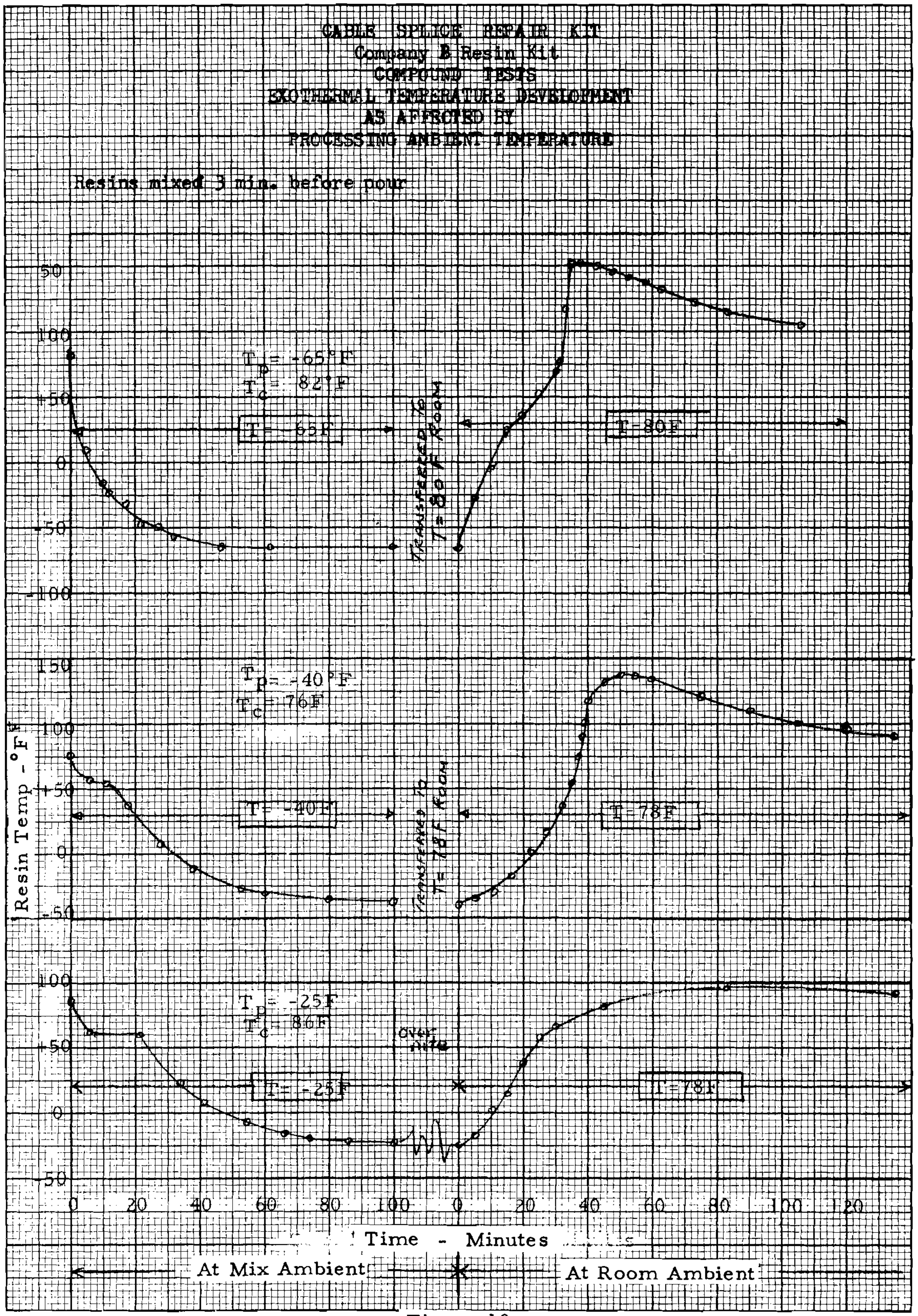

CABLE SPLICE REPAIR KIT
Company B Resin Kit
COMPOUND TESTS
EXOTHERMAL TEMPERATURE DEVELOPMENT
AS AFFECTED BY
PROCESSING AMBIENT TEMPERATURE
Resins mixed 3 min. before pour
T_p = -65°F
T_c = 82°F
T = -65F
T = -80F
TRANSFERRED TO T = 80 F ROOM
T_p = -40°F
T_c = 76F
T = -40F
T = 78F
TRANSFERRED TO T = 78F ROOM
T_p = -25F
T_c = 86F
T = -25F
T = 78F
over nite
Resin Temp - °F
Time - Minutes
At Mix Ambient
At Room Ambient

Figure 10.

The results shown graphically in figure 11 compare the temperature-time characteristic of the potted unspliced cable with that of the resin only as measured in the corresponding 50 ml. compound tests. From these data it appears that the maximum temperatures developed in the potted assemblies are approximately 30°F lower for both compounds. The maximum time duration above 220°F was 18 minutes with Compound A and 26 minutes with Compound B. These periods above the melting point of polyethylene appear too short to cause polyethylene insulation migration within the closely woven or the extruded nylon coverings. The maximum temperature of 270°F obtained with Compound B is too low to cause trouble with the nylon coverings.

The temperature difference of approximately 30°F observed between the inner and outer thermocouple indicates excellent penetration into the tightly assembled unspliced wires.

Cable Splice Tests

Procedures

From the results of the two preliminary phase tests, it appears that the experimental potting temperature is limited to a minimum ambient of 10°F. However, if Compound B is preconditioned at a temperature of 70-90°F, this minimum is lowered to approximately 0°F. It was also observed that mixes and pours could still be made at temperatures as low as -65°F with the room temperature preconditioned resins of both compounds and curves could be accomplished by post conditioning the mix at room conditions.

On the basis of this data, the potting schedules tabulated in table II, columns 4 and 5, were used in evaluating the effectiveness of these compounds in sealing spliced cable composed of the insulating materials listed below. In order to determine the stability of the resins, potting was accomplished with the unmixed materials after preaging from 0 to 10 weeks at 125°F.

1. Type 371065S, MIL-C-13777B Cable, figure 3.
    a. Natural latex rubber, Comp. B, with rayon braid covering.
    b. Natural extruded rubber, Comp. A, with rayon braid covering.

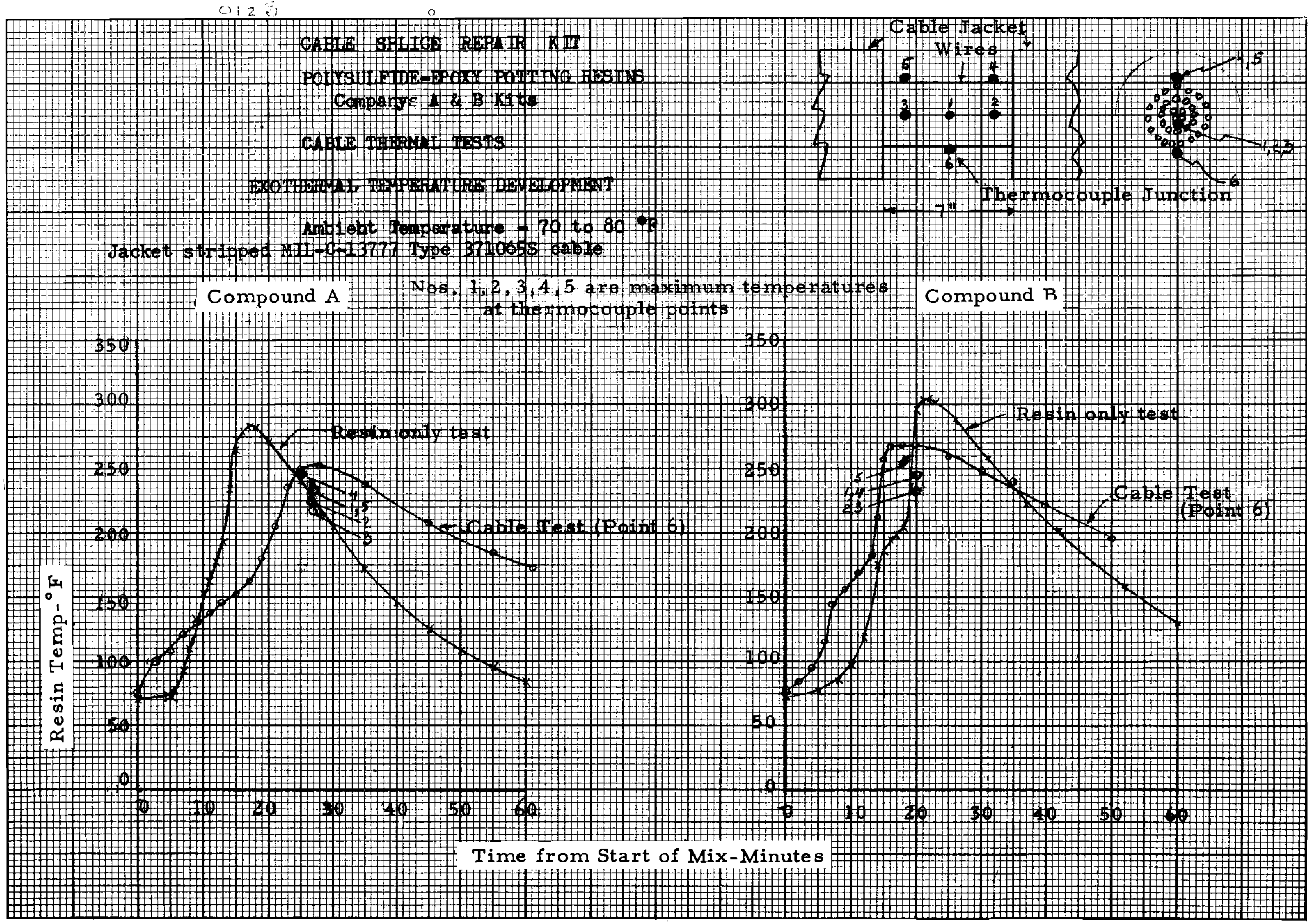

CABLE SPLICE REPAIR KIT
POLYSULFIDE-EPOXY POTTING RESINS
Company A & B Kits
CABLE THERMAL TESTS
EXOTHERMAL TEMPERATURE DEVELOPMENT
Ambient Temperature - 70 to 80 °F
Jacket stripped MIL-C-13777 Type 371065S cable
Cable Jacket
Wires
Thermocouple Junction
7"
Nos. 1, 2, 3, 4, 5 are maximum temperatures at thermocouple points
Compound A
Compound B
Resin only test
Cable Test (Point 6)
Resin Temp - °F
Time from Start of Mix-Minutes
0
50
100
150
200
250
300
350
10
20
30
40
50
60

Figure 11.

Table II. Potting and Test Schedule

Compound	Specimen No.	Specimen Insulation (1)	Resin Precond. Temp°F	Mix and Potting Temp°F	Mechanical Tests Temp°F	1st Test Type	1st Test Cycles	2nd Test Type	2nd Test Cycles	Resin 125°F Age Weeks
A	1301	1a	100	100	-65	I	200	T	2000	0
	1302	1a	70	70	70	T	1000	I	500	10
	1304	1a	NT	25	70	I	200	T	2000	1
	1305	1a	100	100	125	T	1000	T	2000	4
	1306	1a	100	100	70	T	1000	I	500	10
	1307	1a	NT	25	-65	T	1000	I	500	0
	1308	1a	NT	0	125	T	1000	T	2000	10
	1401	2a	100	100	-65	I	200	I	500	0
	1402	2a	70	70	-65	I	200	I	500	10
	1403	2a	70	70	70	I	200	I	500	1
	1404	2a	NT	0	125	I	200	I	500	10
	1405	2b	NT	25	70	I	200	I	500	4
	1406	2b	100	100	-65	I	200	I	500	4
	1201	1b	100	100	-65	I	200	T	2000	0
	1202	1b	70	70	-65	T	1000	I	500	10
	1203	1b	NT	0	-65	T	1000	I	500	4
	1204	1b	NT	25	70	I	200	T	2000	1
	1205	1b	100	100	70	T	1000	T	2000	4
	1206	1b	100	100	70	T	1000	I	500	10
	1207	1b	NT	25	125	T	1000	I	500	0
	1208	1b	NT	0	125	T	1000	T	2000	10
	1209	1b	70	70	125	I	200	T	2000	1
B	2301	1a	100	100	-65	I	200	T	2000	0
	2302	1a	70	70	125	I	200	T	2000	10
	2401	2b	100	100	-65	I	200	I	500	4
	2402	2b	70	70	70	I	200	I	500	0
	2403	2b	70	70	125	I	200	I	500	4
	2404	2b	NT	0	125	I	200	I	500	0
	2405	2b	NT	25	70	I	200	I	500	10
	2406	2b	100	100	-65	I	200	I	500	10

Note: Cable lengths protected by jacket and splice
1200, 1300 and 2300 series -61"
1400 and 2400 series -26"
(1) See Text
NT - Normal room temperature - 70 to 90°F
I - Impact test
T - Twist test

2. Type 211055, MIL-C-13777 Cable, figure 4.

a. Polyethylene, Comp. F, with rayon braid covering.
b. Polyethylene, Comp. F, with extruded nylon covering.

Figure 12 illustrates a typical unpotted spliced specimen of Type 371065S cable. All joints of all test specimens of both cables were made with nylon insulated solderless Burndy Insulink type YSE 14H and YSE 10 connectors crimped with Burndy Tool MR8-33T for the AWG 12 and AWG 18 conductors, and uninsulated solderless Burndy Hyring types YIC 261 and YOC 220 with 3/16" I.D. tinned copper shield tubing, Alpha #1230, connector systems crimped with Burndy Tool MR8PV-11 for the inner core shields. The joints were progressively staggered 1/4" to 3/8" between adjacent wires in the same layer.

The total length of the completed splice between jacket ends was 6" and the maximum overall diameter of the assembled spliced wires was 1 3/4".

The potting mold and fittings were then slipped over the splice openings, fastened in position and finally filled with the mixed potting compounds under the conditions tabulated in table II. In all cases, the potted assemblies were transferred from the environmental chambers after a minimum of 2 hours at the potting ambient temperature.

After a minimum of 3 days at normal room conditions, the specimens were subjected to two series of the mechanical twist (+90° to -90° twist under 50 lbs tensile load) and impact (27.5 lbs -6") tests described in MIL-C-13777C and table II.

After each series of mechanical tests (table II), the cable specimen ends were sealed and exposed to five cycles of temperature-humidity conditions, figure 13. This procedure was adopted to obtain a breathing and condensation condition through very small as well as large faults in the splice seal. The end seals were made by slipping a manila paper envelope containing some cobalt acetate moisture indicator over the ends and taping to the cable jacket. Then two polyethylene bags were slipped over this assembly and also taped, figure 14. However, the first exposure series showed some moisture penetration. After the second series of mechanical tests, the same procedure was used but was finished off by a dip in hot microcrystalline wax. This procedure proved to be effective.

The efficiency of the splice seal was determined by measurements of d.c. insulation resistance, 1000 cps capacity and 60 cps dielectric strength before potting, after potting and after each mechanical-humidity exposure.

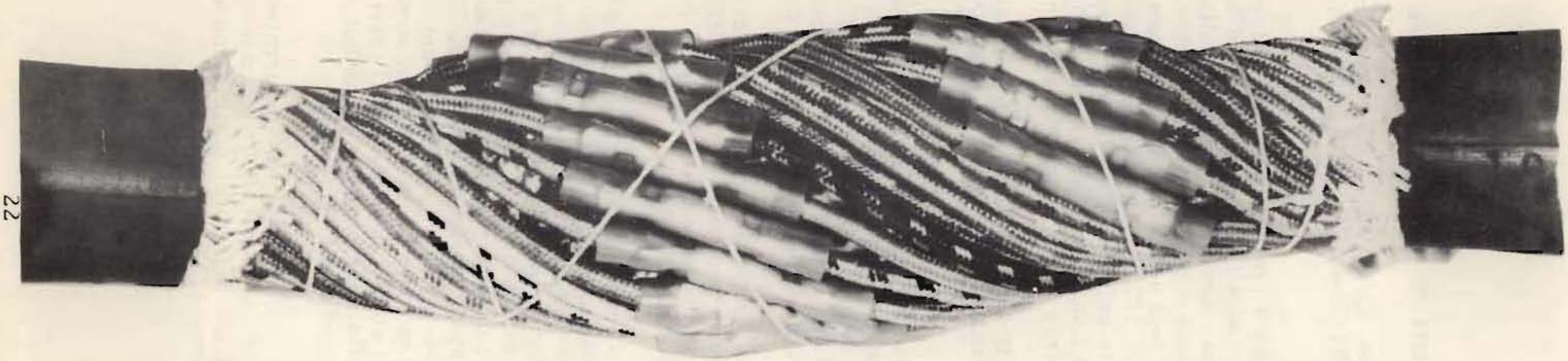


Figure 12. Cable Repair Kit for Multiconductor Cables
Completed Splice Repair of Type 371065S (MIL-C-13777) Cable Before Potting

FORT MONMOUTH HUMIDITY CYCLE

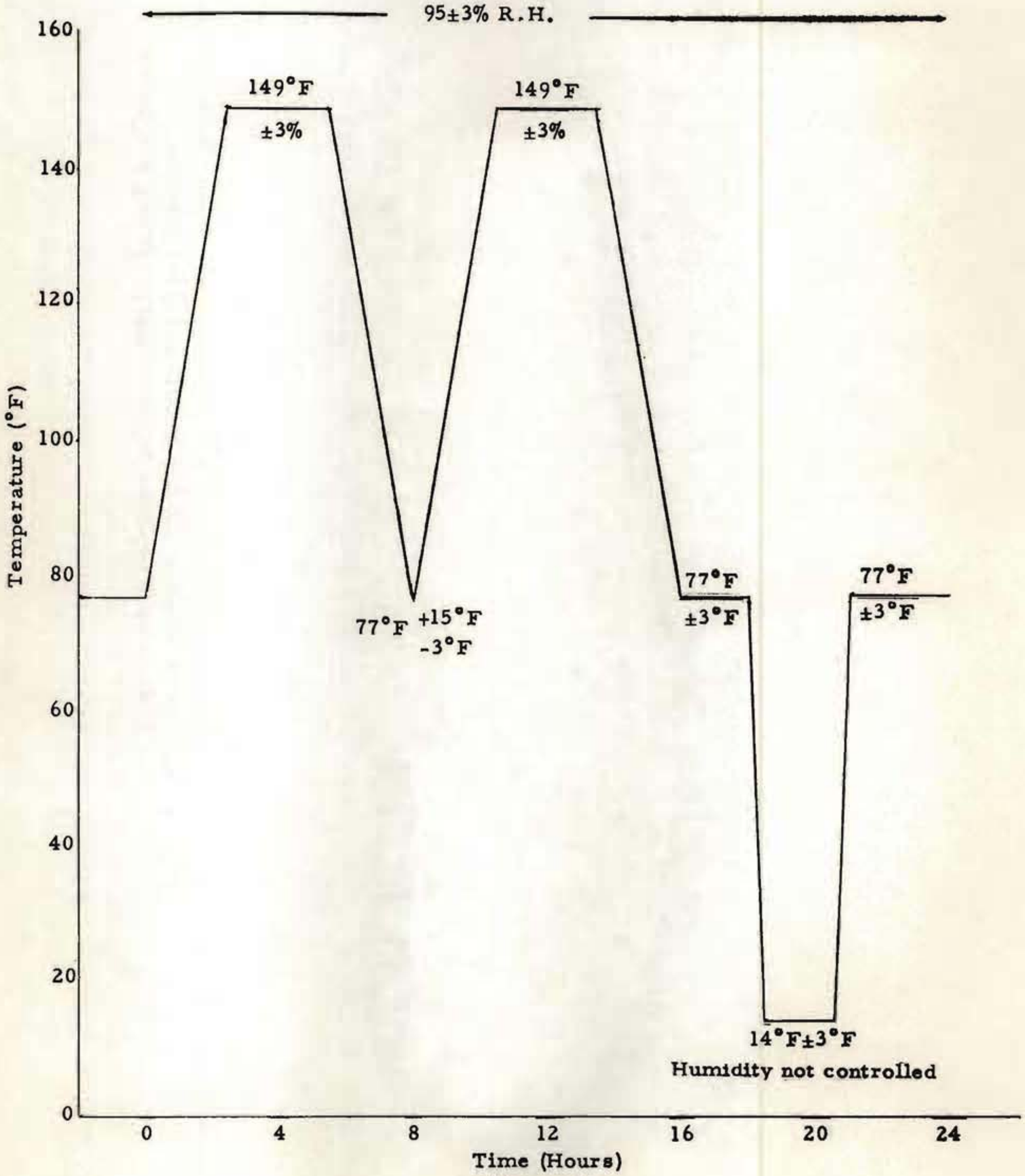


Figure 13.

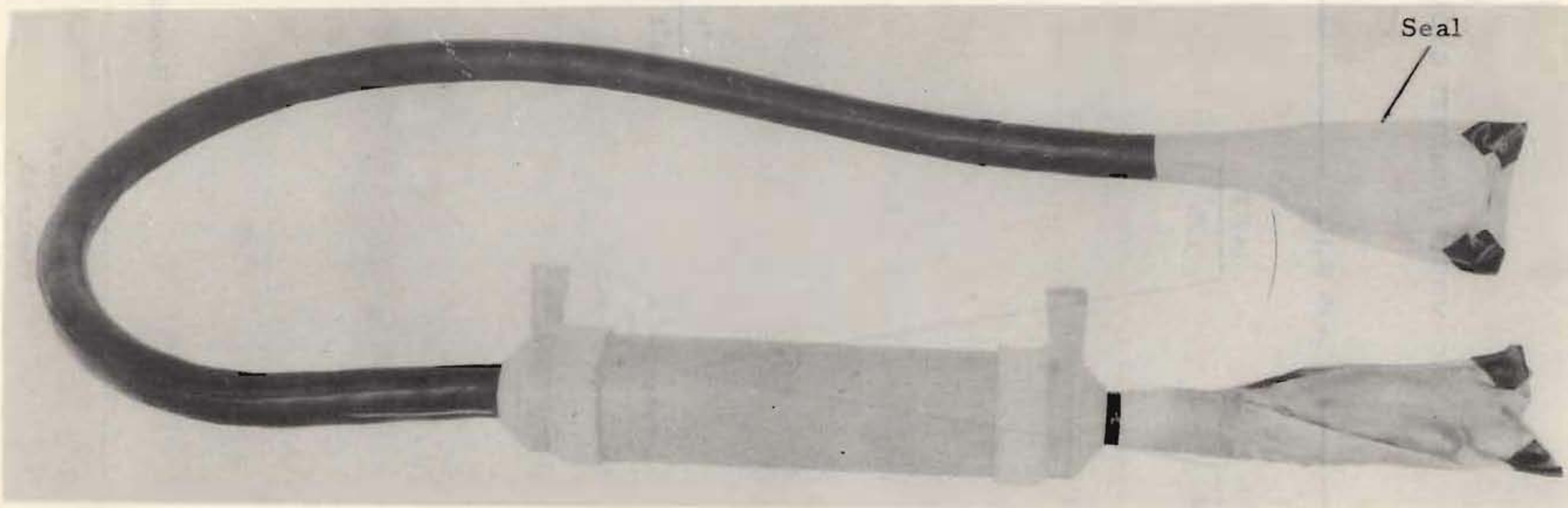


Figure 14. Cable Repair Kit for Multiconductor Cables
Specimen Prepared for Humidity Cycling Exposure

Insulation resistance measurements were made between wire groupings, tables III and IV, at 200 volts d.c. with a Freed Transformer Co. Model 1620 Megohmmeter. Surface leakage was excluded from the measurement by guards formed by wrapping AWG 30 tinned copper wire around the wire insulation of each wire approximately 1 inch from each end.

Capacity measurements were made at 1000 cps between the same wire groupings using a Shallcross Manufacturing Co. Signal Corps Analyzer Type ZM-3/U. All readings were corrected for the 20 mmf instrument lead capacity.

Dielectric strength tests were made between wire groupings, tables III and IV, with a General Electric Co. High Voltage Test Set Type K rated at 5 KVA, 60 cycles, 10 KV. In these tests, the applied voltage was first raised from zero to 500 volts. Every 30 seconds thereafter the voltage was raised in 500 volt steps until failure occurred or the maximum attainable voltage of 10 KV was reached. After 1 minute at this voltage, the test was discontinued.

All the measurements were made at normal room temperature conditions and the results are summarized in tables V to VIII.

"Noise" tests for the detection of faulty contact in the crimped connectors were made using several techniques. However, none of the tests showed any poor contact evidence. Therefore, these tests were discontinued after the initial series of tests.

Effect of Potting

The effect of potting at 0, 25, 75 and 100°F on the electrical properties is graphically summarized in figures 15 to 17. Both of the potting compounds penetrated well into the shielded pairs of the innermost layer of the 371065S cable. This is illustrated by figure 15C.

In many cases, dielectric failures of the unpotted splices were actually flashovers between the ends of the conductor connectors. After potting, no flashovers were observed and all failures occurring at above 6000 volts were due to breakdown of wire insulation. Some failures at lower voltages did occur at the cable ends where the wires started to separate as they came out of the cable assembly.

The most marked improvement took place between wires of adjacent layers of both cable types and of the shielded pairs of the 37 conductor cable. The improvement between the intermediate layers of the 37 conductor cable was not of the same order. Both compounds showed essentially the same order of improvement.

Table III. Schedule of Tests - Type 371065S Cable

Wire Grouping Designations

Layer 3 Color Field	Code Trace	Designation	Color Field	Code Trace	Designation
Orange Orange Orange	White Black -	1	Blue Green Orange	- Yellow Green	5
Black Blue Green	Orange Orange Orange	2	Orange White Red	Red Red Orange	6
Red Red Red	White Black -	3	Yellow Yellow Green	Black - -	7
Green Green Brown	White Black -	4			

Layer 2					
White White Red Black Green Red	Orange - Blue - Blue Yellow	20 21 22 23 24 25	Blue White White Black Black Red	White Black Green White Green Green	26 27 28 29 30 31

Layer 1					
Blue Black	Red Red	32 33	Yellow Green	Red Red	34 35
Shield		36	Shield		36

Test Groupings and Schedule

Test	Layer 3 vs Layer 2		Layer 2 vs Shield		Layer 1 vs Shield	
Before Potting						
1-Diel. Str.	1 4	20 26	21 27	36 36	34	36
2-Ins. Res. 3-Capacity	2 5 6	22 28 30	23 29	36 36	33	36
After Potting						
4-Ins. Res. 5-Capacity	Same as Test Nos. 2 and 3					
6-Diel. Str.	2 5	22 28	23 29	36 36	33	36
7-First Mech 8-Humidity	See Table II					
9-Ins. Res. 10-Capacity	3 6 7	24 30 30	25 31	36 36	34 35	36 36
11-Oven Dry	24 hrs. at 150°F					
12-Ins. Res. 13-Capacity	Same as Test Nos. 9 and 10					
14-Second Mech 15-Humidity	See Table II					
16-Ins. Res. 17-Capacity	Same as Test Nos. 9 and 10					
18-Diel. Str.	3 6	24 30	25 31 24	36 36 36	35	36

Table IV. Schedule of Tests - Type 211055 Cable

Wire Grouping Designations

Layer 2

Color Field	Code Trace	Designation	Color Field	Code Trace	Designation
Blue	-	1	Red	Black	9
Orange	White	2	Red	-	10
Orange	-	3	Yellow	Red	11
Green	White	4	Yellow	Black	12
Green	Black	5	Yellow	-	13
Green	-	6	Blue	White	14
Orange	Black	7	Blue	Red	15
Red	White	8			

Layer 1

Color Field	Code Trace	Designation	Color Field	Code Trace	Designation
White	-	16	Black	-	19
White	Black	17	Red	Green	20
Black	White	18	Red	Yellow	21

Test Groupings and Schedule

Test	Layer 2 vs Layer 2		Layer 1 vs Layer 2	
Before Potting				
1-Diel. Str	1 3	2 4	3	16
2-Ins. Res 3-Capacity			5, 6, 7 7, 8, 9 10, 11, 12 13, 14, 15	17 18 19 20
After Potting				
4-Ins. Res. 5-Capacity	Same as Test Nos. 2 and 3			
6-Diel. Str.	5 6	6 7	7	17
7-First Mech. 8-Humidity	See Table II			
9-Ins. Res. 10-Capacity			7, 8, 9 10, 11, 12 13, 14, 15	18 19 20
11-Oven Dry	24 Hrs at 150°F			
12-Ins. Res. 13-Capacity	Same as Test Nos. 9, 10			
14-Second Mech 15-Humidity	See Table II			
16-Ins. Res. 17-Capacity	Same as Test Nos. 9, 10			
18-Diel. Str.	7 8 10 11	8 9 11 12	7 10	18 19

Table V. Cable Splice Tests - Electrical Measurements

Pour Temp. 100°F

		1000 ~ Cap - pF					Ins. Res. - T ohms					Diel. Str. - Kv.			Test Electrodes		Mechanical Test Remarks
		Original		After Mech. Tests			Original		After Mech. Tests			Original		After Mech. Tests			
Specimen No.	Mech. Test Temp. °F	A. S.	After Potting	Test 10[1]	After Dry	Test 17[1]	A. S.	After Potting	Test 9[1]	After Dry	Test 16[1]	A. S.	After Potting		Capacity and Ins. Res.	Diel. Str.	
1301	-65	80	90	>	95	-	.5-1.0	1.5-2.0	0-.5	.5	-	10+	10	0	(3) 3 vs (1) 2	(3) 3 vs (1) 2	Cracked completely through splice on impact tests
1305	125	88	92	100		97	1.0	2.0	2.0		2.0	6-10+	10	10+	(3) 3 vs (1) 2		Open circuits developed on twist tests
1306	75	82	87	112	95	92	1.0	.7-2.0	1.0-2.0	1.5-2.0	2.0	7-10+	10	10	(3) 3 vs (1) 2		
2301	-65	82	92	102		97	.75-1.5	1.5-2.0	2.0		1.0-2.0	8-10	10	10+	(3) 3 vs (1) 2		Open circuit developed on second mechanical twist test
1201	-65	105	107	172	125		.75-2.0	2.0	.00-.8	.003-2.0	-	7.5	10	0	(3) 3 vs (1) 2		Cracked completely through splice on impact tests
1205	75	105	107	172	145	135	2.0	2.0	1.5-2.0	2.0	2.0	10+	10	10+	(3) 3 vs (1) 2		Open circuit developed on second mechanical twist test
1206	75	110	107	170	130	142	2.0	2.0	2.0	1.5-2.0	2.0	10+	10	10+	(3) 3 vs (1) 2	(1) 2 vs (1) 2	
1401	-65	42	45	>	55	-	2.0	2.0	0	0-2.0	-	10+	10+	0	(3) 2 vs (1) 1	(1) 2 vs (1) 1	Cracked completely through splice on impact tests
1406	125	37	40	47		42	2.0	2.0	2.0		2.0	5-10	10+	10+	(3) 2 vs (1) 1		
2401	-65	35	45	60	50	55	2.0	2.0	.6-2.0	2.0	2.0	8-9	10+	10+	(3) 2 vs (1) 1		
2406	-65	32	45	50		48	2.0	2.0	2.0		2.0	8-9	10+	10+	(3) 2 vs (1) 1		
1301	-65	170	170	>	180		.15-.4	.25-.5	0	.006-.01	-	5-8.5	7.5-9.5	0	S vs (1) 2	S vs (1) 2	
1305	125	170	185	180		182	.5	.75	.5		.5	4.5-6	8	9			
1306	75	170	180	200-240	183	180	.15-.3	.3-.6	.3-.6	.25-.5	.25-.5	5	6-7.5	8.5			
2301	-65	157	180	200		210	.15-.35	.45-.6	.2-.35		.25-.4	3.5-6	7	8.5			
1201	-65	190	192	310	210	-	.5-1.0	1.0-1.5	0.5	20M-.3	0-.3	5	10	8.0			
1205	75	192	195	292	220	222	.45-.7	1.5	.2-.7	.8	1.0	8.5-10+	10	10+			
1206	75	200	197	275	240	257	.45	1.0	.9-1.0	1.0	1.0-1.5	7	8-10	10+			
1301	-65	260	267	>	290	-	.2	.9	0	.1-.8	-	5	8	0	S vs (1) 1	S vs (1) 1	
1305	125	280	280		290	280	1.0	1.0	.6		.5-1.0	4	7	9			
1306	75	265	265	320	285	285	.45	1.5	.7-1.0	.65	.65	4.5	9	9			
2301	-65	265	265	292		292	.35	.7	.45		.5	3	9	7			
1201	-65	320	310	330	275	-	.5	1.5	0-.25	.1-.15	-	4.5	10	0			
1205	75	300	295	330	290	290	.7	2.0	1.0	.1-.5	20M-1.0	9	10	1			
1206	75	317	305	335	285	312	.5	1.5	.9-1.0	1.0	.6-.8	4	9	10			

Legend -
- > - Could Not Be Measured
- S - Shield Braid Covering
- ( ) - No of Wires
  - Code for Test Electrodes - Ex. (3) 3 vs (1) 2 = 3 wires of layer 3 test against 1 wire of layer 2
- A.S. - As Spliced
- pF - Picofarads (10^{-12} farads)
- T - Tera (10^{12})
- [1] - See Tables III & IV
- AO - Arcover

Table VI. Cable Splice Tests - Electrical Measurements

Pour Temp. 70°F

		1000 ~ Cap - pF					Ins. Res. - T ohms					Diel. Str. - Kv.			Test Electrodes		
		Original		After Mech. Test			Original		After Mech. Test			Original		After Mech Tests			
Specimen No.	Mech. Test Temp. °F	A. S.	After Potting	Test 10[1]	After Dry	Test 17[1]	A. S.	After Potting	Test 9[1]	After Dry	Test 16[1]	A. S.	After Potting		Capacity and Ins. Res.	Diel Str.	
1302	75	82	85	112	92	90	.75-1.0	1.5-2.	1.0-2.0	2.0	2.0	8.5	10	10+	(3) 3 vs (1) 2	(3) 3 vs (1) 2	Open circuit developed on the first mechanical twist test
2302	125	87	87	92	90	92	.75-2.0	2.0	2.0		2.0	8	10	10+			
1202	-65	112	107	132		125	1.0-2.0	2.0	1.5-2.0		2.0	9.5-10+	10	9-10+			
1209	125	102	105	125	120	132	1.0-2.0	2.0	2.0	2.0	2.0	9.10+	10	10+			
												5.5-10+		A0		(1) 2 vs (1) 2	
1402	75	42	42	50	45	42	2.0	2.0	2.0	2.0	2.0	10+	10+	10+	(3) 2 vs (1) 1	(1) 2 vs (1) 1	
												5-9.5		A0-10			
1403	125	42	45	45		45	.75-1.0	2.0	2.0		2.0	7.5-10	10	10			
2402	75	35	45	60	50	52	2.0	2.0	2.0		2.0	10+	10+	10+			
2403	125	35	45	47		50	2.0	2.0	.5-.8	2.0	2.0	8-10+	10+	10+			
1302	75	157	177	115-200	115-170	105-167	.15-.3	.3-.6	.27	.3	.4	7.5	8.5	8	S vs (1) 2	S vs (1) 2	
2302	125	160	190	140-185	135-187	140-190	.2-.5	.2-.5	.25		.27	5.5	7-8.5	8.5			
1202	-65	212	205	220		262	.4-.75	1.0-1.5	.6-.8		.9-1.5	3	10	10+			
1209	125	180	205	212	220	247	.45	1.0-1.5	1.0-1.5	1.0-1.5	1.0-1.5	6	10	10			
1302	75	270	265	320	290	280	.35	1.0	.3-.8	.6	.9	5	8	8	S vs (1) 1	S vs (1) 1	
2302	125	260	270	285	280	285	.6	.3	.2		.08-.25	5	8	9			
1202	-65	330	310	300->		285->*	-75	1.5	0-.8		*0-1.0	3	9	0			* - Short circuit
1209	125	310	302	295	295	300	.3	1.5	1.5	1.5	1.5-2.0	4	10	10			

Legend - See TABLE V

Table VII. Cable Splice Tests - Electrical Measurements
Pour Temp. 25°F

		1000 ~ Cap - pF					Ins. Res. - T ohms					Diel. Str. - Kv			Test Electrodes	
		Original		After Mech Test			Original		After Mech. Test			Original		After		
Specimen No.	Mech. Test Temp. °F	A. S.	After Potting	Test 10[1]	After Dry	Test 17[1]	A. S.	After Potting	Test 9[1]	After Dry	Test 16[1]	A. S.	After Potting	Mech. Test	Capacity and Ins. Res.	Diel. Str.
1304	75	80	90	112	90	92	.75-1.0	2.0	2.0	2.0	2.0	10+	10+	10+	(3) 3 vs (1) 2	(3) 3 vs (1) 2
1307	-65	82	92	102		115	1.0	2.0	2.0		2.0	8.5-10+	6.5-10+	A0		
1204	75	117	120	175	142	135	2.0	2.0	2.0	2.0	2.0	7.5-10+	10+	10+		
1207	125	110	115	112		127	2.0	2.0	2.0		2.0	8.5	10+	10+		
1405	-65	37	40	47	42	45	2.0	2.0	2.0	2.0	2.0	6-9.5 10 8	10+	10+	(3) 2 vs (1) 1	(1)2 vs (1)2 (1)2 vs (1) 1
2405	75	32	42	52	44	47	2.0	2.0	2.0		2.0	8.5	10+	10+		
1304	75	170	180	190-220	190	192	.15-.4	.2-.4	.2-.4	.3-.5	.25-.5	4-7	7	6-10	S vs (1) 2	S vs (1) 2
1307	-65	157	188	190		240	.15-.4	.05-.1	.25		.03-.4	5.5-7.5	5-7.5	A0		
1204	75	200	207	320	255	240	.5-.75	.35	.8	.55	.55	6-9.5	10+	10+		
1207	125	205	210	212		215	.7-1.0	.35	.7-.8		.7	7.5	10+	10+		
1304	75	265	265	310	280	282	.75	.7	.6	.6	.7	4	7.5	A0	S vs (1) 1	S vs (1) 1
1307	-65	260	265	290		312	.4	.08	.45		.37	5	10	A0		
1204	75	310	300	332	295	298	.75	.3	.8-.03	.4-.002	.3-.001	5.5	10+	10		
1207	125	300	310	295		300	1.5	.05	.9-1.0		.8-1.0	6	9.5	10+		

Legend - See Table V

Table VIII. Cable Splice Tests - Electrical Measurements

Pour Temp. 0°F

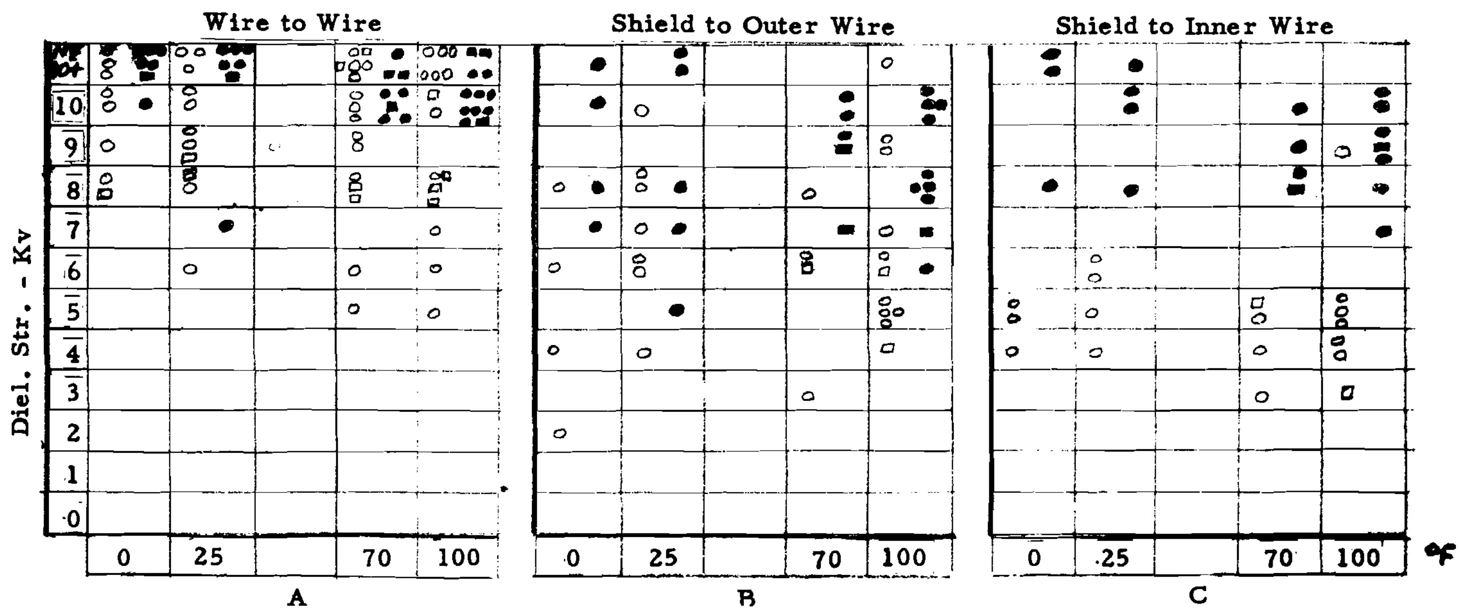
		1000 ~ Cap - pF					Ins. Res. - T ohms					Diel Str. - Kv			Test Electrodes		Remarks
		Original		After Mech. Tests			Original		After Mech. Tests			Original		After Mech Tests			
Specimen No.	Mech. Test Temp. °F	A. S.	After Potting	Test 10[1]	After Dry	Test 17[1]	A. S.	After Potting	Test 9[1]	After Dry	Test 16[1]	A. S.	After Potting		Capacity and Ins. Res.	Diel Str.	
1308	125	82	92	97		90	.75-2.0	2.0	2.0		2.0	9.5-10+	10+	10+	(3) 3 vs (1) 2	(3) 3 vs (1) 2	Open circuit developed on 2nd mechanical twist test
1203	-65	117	117	137		125	1-2	2.0	2.0		2.0	10+	10+	10+			
1208	125	112	117	122		132	2.0	2.0	2.0		2.0	8.5	10+	10+			
												10+		10+			
1404	75	42	42	45	45	50	2.0	2.0	2.0	2.0	2.0	10	A0-10+	5-10+			
												7.5				(1) 2 vs (1) 2	
2404	125	32	42	47	47	47	2.0	2.0	2.0	2.0	2.0	8	10+	10+	(3) 2 vs (1) 1	(1) 2 vs (1) 1	
1308	125	162	192	200		* 97-180	.15-.3	.25-.5	.2-.6		.25-.5	2-4.5	7.5-8	4-6	S vs (1) 2	S vs (1) 2	* - Open wire
1203	-65	205	202	287		222	.48	1.0	.8-.9		.8	6	10	10			
1208	125	205	197	215		220	1.0	1.0-1.5	1.0-1.5		.8-1.5	8	10+	10+			
1308	125	265	265	287		282	.35	.8	.5		.7	4.5	8	8	S vs (1) 1	S vs (1) 1	
1203	-65	320	310	305		298	.45	.7	.25-.6		.9	5	10+	10			
1208	125	310	310	295		302	1.5	1.0	1.5		1.5	5	10+	10			

Legend - See Table V

Cable Repair Kit
Evaluation of Polysulfide-Epoxy Potting Compounds

Effect of Potting
on
60 ~ AC Dielectric Strength

Spliced Cable - MIL-C-13777, Type 371065S and Type 211055



Pour Temperature °F

Legend -
Open Symbols - Before Potting
Closed Symbols - After Potting
O - Compound A
▢ - Compound B
NF - No Failure

Figure 15.

Cable Repair Kit
Evaluation of Polysulfide-Epoxy Potting Compounds

Effect of Potting
On
DC Insulation Resistance

Legend -
Open Symbols - Before Potting
Closed Symbols - After Potting
O - Compound A
□ - Compound B

Spliced Cable - MIL-C-13777, Type 371065S and Type 211055

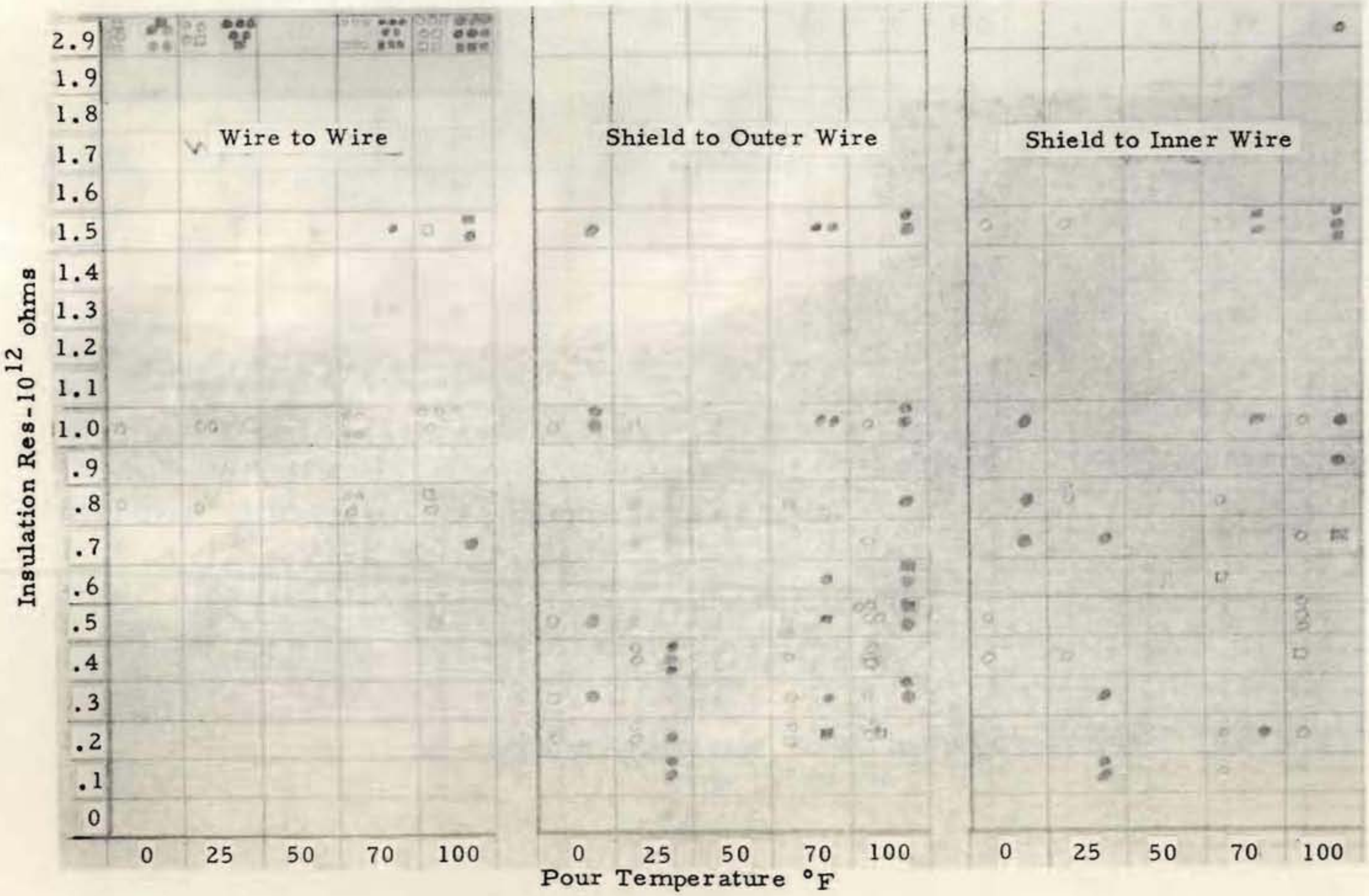


Figure 16.

Cable Repair Kit

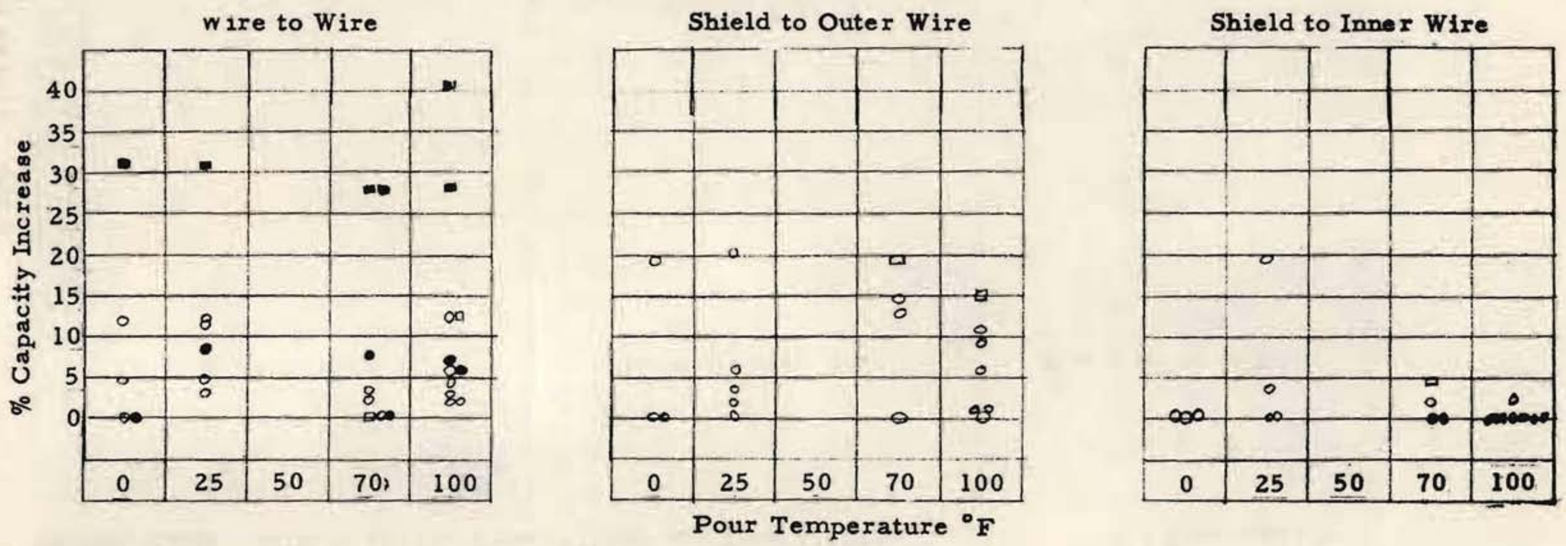
Evaluation of Polysulfide - Epoxy Potting Compounds

Effect of Potting

On

1000 ~ AC Capacity

Spliced Cable - MIL-C-13777, Type 371065S and Type 211055



Legend -

O Compound A } 37/C - Cable and splice overall length - 61 inches
□ Compound B

● Compound A } 21/C - Cable and Splice overall length - 26 inches
■ Compound B

Figure 17.

In general, the rise in dielectric strength was uniform over the entire potting temperature range investigated.

The insulation resistance between wires in the outer adjacent layers was significantly raised by potting. However, no corresponding significant effect on the insulation resistance between the shield and adjacent wires, either external or internal was observed. This was especially evident when potting was done at 25°F ambient in which case slightly lower values were observed. However, even the lowest values obtained were of the order of 10^5 megohms which is still a very satisfactory insulation resistance.

As a result of potting, capacity increases varied from 0 to 20% except for the polyethylene insulated wire cable which exhibited increases from 25-40% when potted with Compound B. However, this represents an increase of 5-10 mmf which may be due to experimental error only. The potted capacities of this particular series with both resins were within the range of 40-45 mmf. The effect of pouring ambient temperature was not significant.

Effect of Mechanical Tests

At -65°F testing temperature, Compound A potted splice specimens started to fail under impact testing by circumferential cracking (fig. 18). Upon examination, it appears that the splice was being tested as a flex beam supported at both ends by the raised end cap section. When these end caps were trimmed or removed entirely to remove these support points no further physical failures were observed at all testing temperatures. The only visual effect resulting from impact by the anvil was a deformation of the sleeve at the point of impact, figure 19.

The only effect of impact testing on the Compound B potted splices was a denting or splitting of the mold at all test temperatures, figure 20.

No movement of the cable relative to the splice was observed as a result of the twist testing. Figure 21 shows a typical specimen after subjection to the twist test.

Seal effectiveness as determined by the electrical measurements was not affected by the mechanical "torture" except where cracking of the splice assembly potted with Compound A occurred under impact at -65°F. Splices potted at ambient temperatures of 0 to 100°F were equally effective, figures 22 and 23.

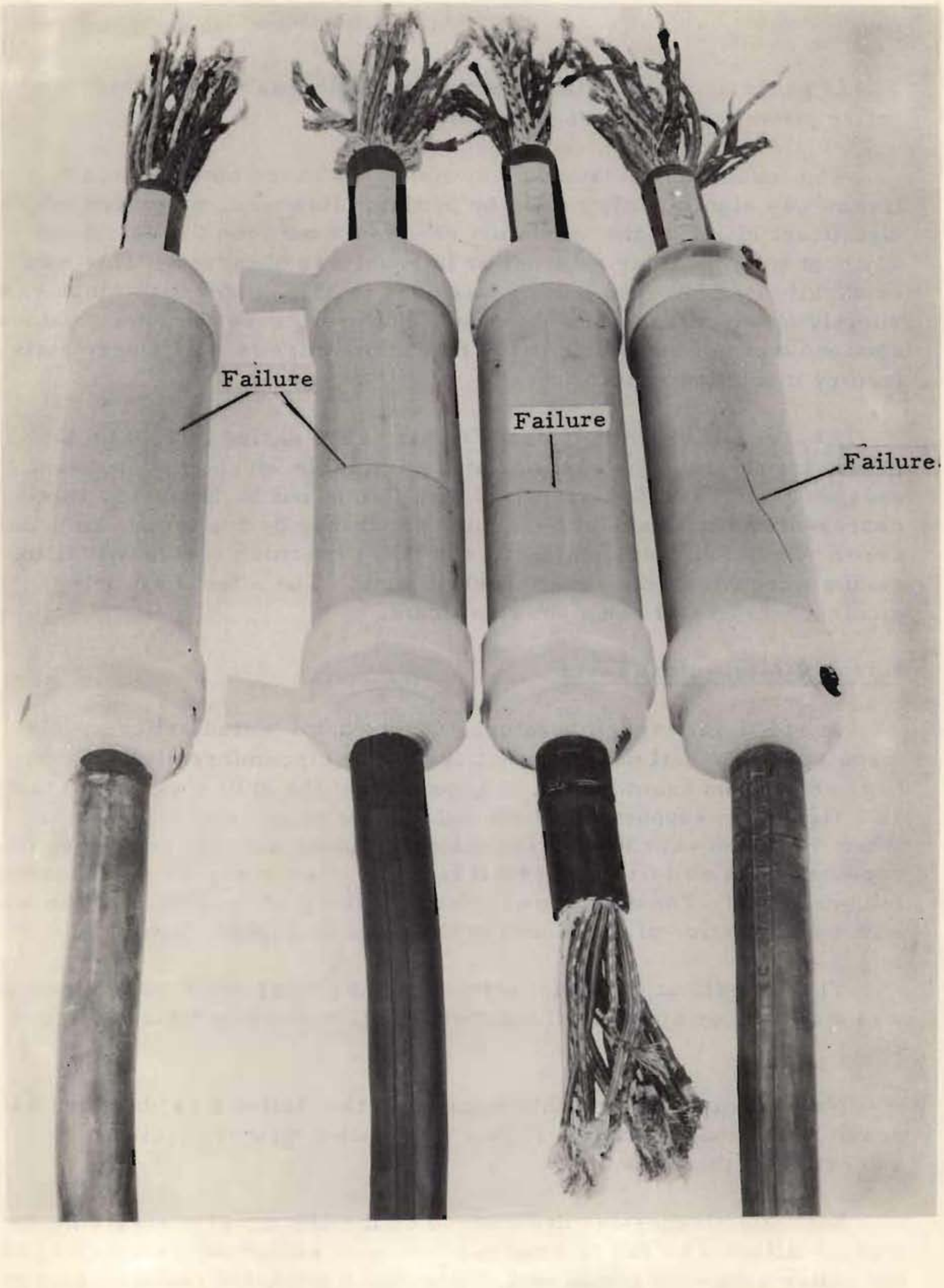


Figure 18. Cable Repair Kit for Multiconductor Cables
Impact Test Failures at -65°F - Company A Kit

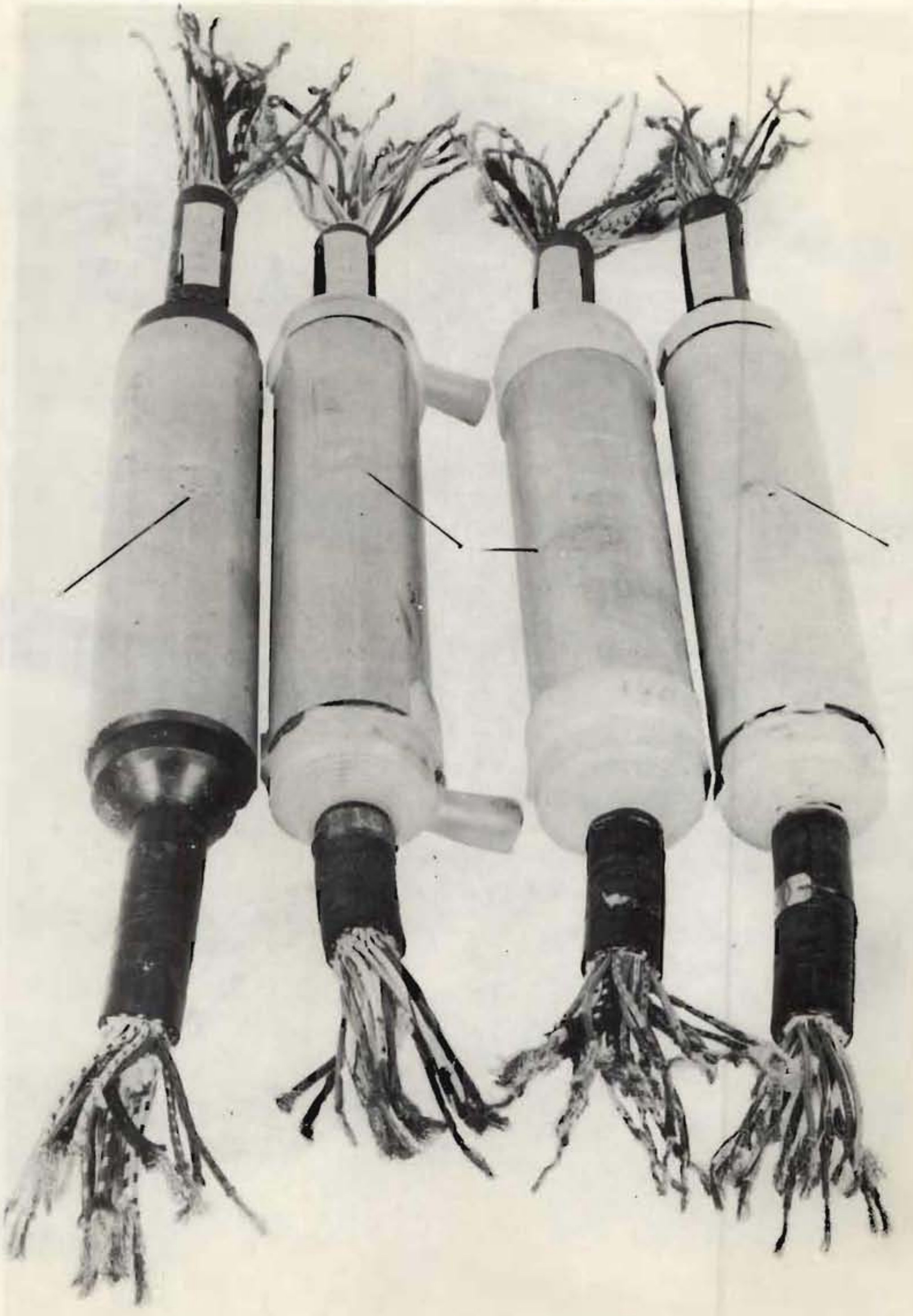


Figure 19. Cable Repair Kit for Multiconductor Cables - Appearance after Impact Tests - Company A Kit

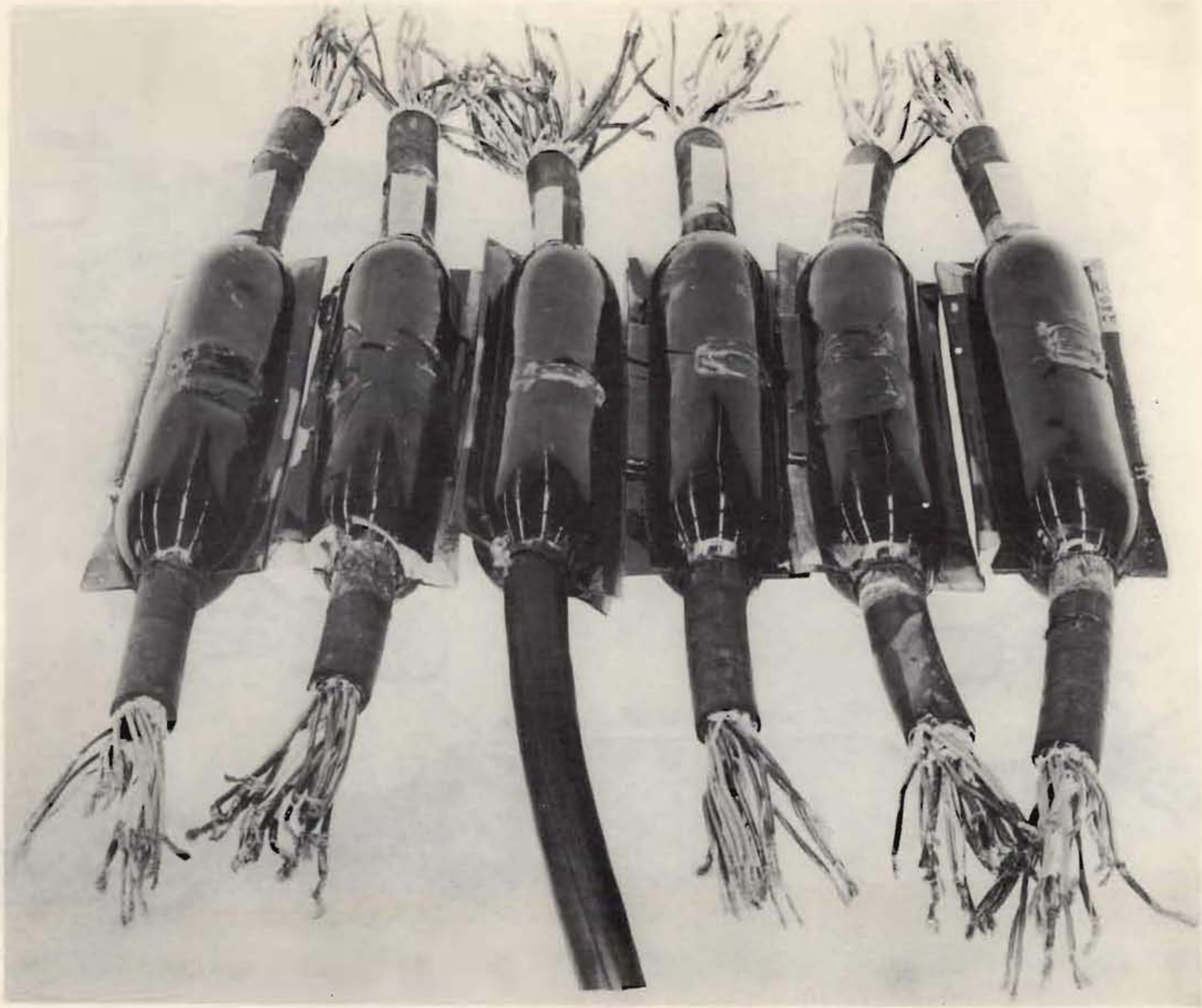


Figure 20. Cable Repair Kit for Multiconductor Cables
Appearance after Impact Tests - Company B Kit

Figure 21. Cable Repair Kit for Multiconductor Cables
Twist Test - Relative Movement between Cable and Splice After Test

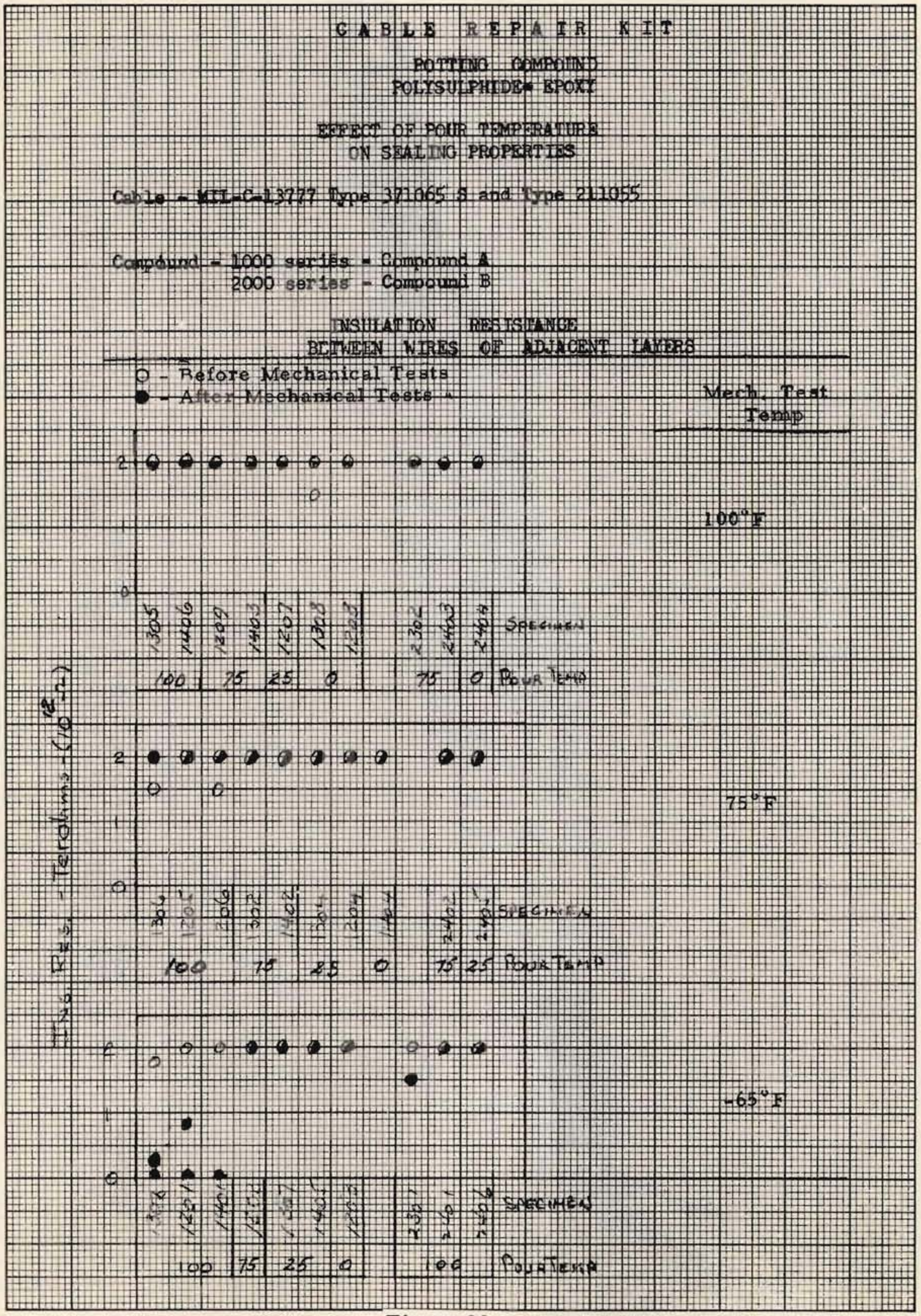

CABLE REPAIR KIT
POTTING COMPOUND
POLYSULPHIDE- EPOXY
EFFECT OF POUR TEMPERATURE
ON SEALING PROPERTIES
Cable - MIL-C-13777 Type 371065 S and Type 211055
Compound - 1000 series - Compound A
2000 series - Compound B
INSULATION RESISTANCE
BETWEEN WIRES OF ADJACENT LAYERS
O - Before Mechanical Tests
● - After Mechanical Tests
Mech. Test
Temp
100°F
75°F
-65°F
Specimen
Pour Temp
Ins. Res. - Teraohms - (10^{12} Ω)

Figure 22.

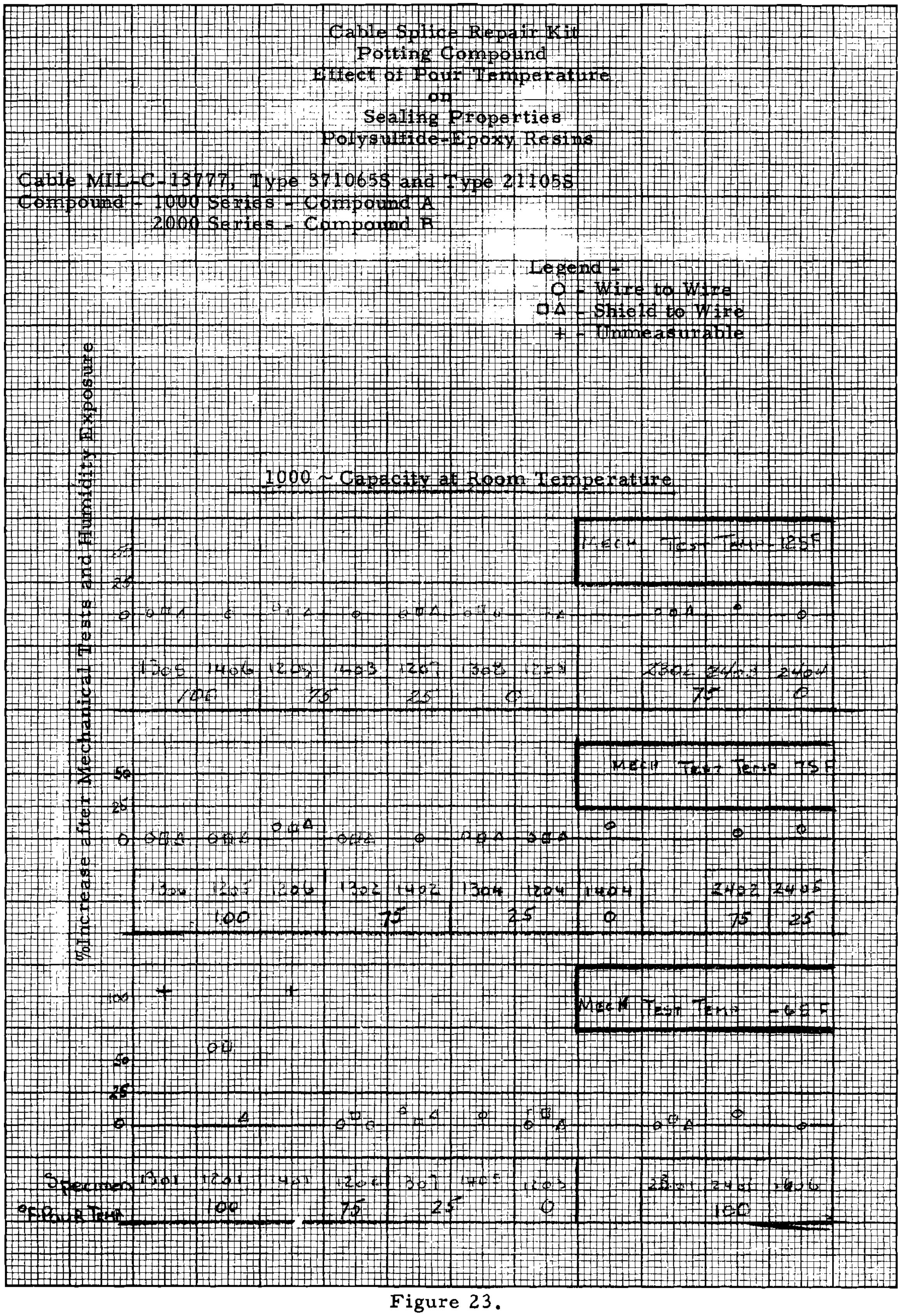

Cable Splice Repair Kit
Potting Compound
Effect of Pour Temperature
on
Sealing Properties
Polysulfide-Epoxy Resins
Cable MIL-C-13777, Type 3710655 and Type 21105S
Compound - 1000 Series - Compound A
2000 Series - Compound B
Legend -
O - Wire to Wire
□Δ - Shield to Wire
+ - Unmeasurable
% Increase after Mechanical Tests and Humidity Exposure
1000 ~ Capacity at Room Temperature
Mech Test Temp 125F
Mech Test Temp 75F
Mech Test Temp -65F
Specimen
°F Pour Temp

Figure 23.

SUMMARY OF RESULTS AND CONCLUSIONS

1. Under the conditions of this investigation, precondition-mix-pour at 74°F and 100°F and precondition at 70-90°F - mix and pour at 0°F and 25°F, both polysulfide-epoxy resin systems were effective in protecting multiconductor cable splice repairs against mechanical abuse (twist and impact) over the temperature range of -65°F and 125°F. These materials were also effective in maintaining an adequate seal against moisture penetration under cycling humidity-condensation conditions and in maintaining excellent dielectric integrity under this mechanical abuse.

2. Nylon insulated crimp type solderless wire connectors and uninsulated crimp type solderless braided shield connectors gave very satisfactory performance during this investigation. No continuity or insulation failures occurred as a result of potting or subsequent mechanical abuse conditions in a total of 918 wire connections and 36 shield connections. The long time (10-20 minutes) dielectric breakdown strength, after potting, of the wire and connector insulations was generally 10 KV or over for two insulation thicknesses (wire to wire) and 6-9 KV for single thickness insulations (wire to shield).

3. Mixing the components and pouring of splicing Compound A is limited to a minimum temperature of 50°F if the components are preconditioned at the same temperatures. This is due to the excessive viscosity of the material below 50°F and the "pile-up" which occurs when filling the associated splice mold through the small funnel openings.

4. Under the same conditions, the minimum processing temperature limit for Compound B is of the order of 25°F. The large fill opening in the mold provided with this cable splice repair kit avoids the complication of "pile-up" experienced with the Compound A system.

5. Lowering of the minimum mix and pour temperature limit to 0°F can be accomplished by preconditioning the compound components of either materials at ambient temperatures above 70°F.

6. The reaction between the component parts of Compound A is completely inhibited at ambient mix temperatures below 5°F. Pourability of the mixed components is very poor even when 70°F preconditioned components are used due to the very rapid cooling occurring at the low mix and pour ambient temperatures. This does not take place with Compound B until the ambient temperature drops to -10°F. However, when transferred, after potting, to an environmental ambient

of 70°F or greater, a delayed reaction occurs and the compound appears to cure with no observable physical difference from the uninhibited reacted materials.

7. The exothermal temperatures developed during the curing stage of the compounds is a function of the ambient temperature. Under the conditions of this investigation, variations in these developed temperatures appeared to have no effect on the ultimate properties of the potted splice. Although temperatures as high as 360°F were developed at 100°F ambient, no adverse effects on the dielectric materials were observed. At no time did the temperature remain above 220°F for more than 26 minutes.

8. Both compounds appear to have excellent storage capabilities in the unmixed condition. Potted splice repairs made with resins aged for 10 weeks at 125°F performed as well as those made with unaged materials.

RECOMMENDATIONS

1. It is recommended that the crimp type insulated solderless connector be adopted for connecting conductors of a cable splice system to supersede the soldering techniques of Army Technical Manual TM 1649. It is also recommended that the shield braid of the involved cables, if present, be splice connected with the proper crimp type uninsulated ring connectors. These are exemplified by Burndy Corp. Insulink and Hyring connectors.

2. It is recommended that the potting method using the polysulfide-epoxy resins A and B be adopted to supersede the present vulcanizing tape method, Army Technical Manual TM 9-1649.

3. The molds included in the two suppliers' repair kits are not entirely satisfactory for field use. It is recommended that a mold be designed of such material as .030" cellulose acetate butyrate, vinyl polymer or co-polymer, or nylon with large fill openings and smooth continuous exterior contour. Sleeves which can be cut to desired lengths with end caps provided with large fill openings and are easily removed after potting may be adequate. Consideration in design should be given also to potting by a pressure gun injection technique which would provide greater latitude in the material and faster fill.

4. In view of the high exothermal temperatures developed in the reactions between the resin components, it is recommended that the upper allowable ambient mix and pour temperatures be limited to 100°F.

5. For use at below 50°F ambient, it is recommended that the two-part component package be preconditioned at above 70°F before mixing. This can be accomplished by utilizing body heat under the outer garment worn by the splicer.

6. Although it appears that successful splice systems can be potted at temperatures below 0°F, it is recommended that 25°F be adopted as the allowable low limit.

7. In order to assure adequate quality control of the components of the splice repair kit, it is recommended that specifications covering the materials and design be formulated.

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